
NEW RECORDS OF MIDDLE AND LATE MIOCENE PERISSODACTYLA AND ARTIODACTYLA FROM THE WESTERN BORDER OF THE SAN JOAQUIN VALLEY, DIABLO RANGE, FRESNO COUNTY, CALIFORNIA

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ABSTRACT. A mitigation project has resulted in the discovery of a highly significant new Miocene vertebrate fossil locality in the Temblor Formation along Monocline Ridge, Diablo Range, Fresno County, California. Additional Miocene vertebrate fossil localities were also discovered in the overlying Oro Loma Formation along Monocline Ridge. These localities have yielded four superposed vertebrate assemblages that range in age from the middle Miocene to the late Miocene (Barstovian through Hemphillian North American Land Mammal Ages). Of the perissodactyls and artiodactyls recovered during the project, the following taxa are identified and described: cf. *Peraceras* sp., *Archaeohippus mourningi*, *Desmatippus avus*, “*Merychippus*” *californicus*, “*Merychippus*” *brevidentatus*, “*Merychippus*” cf. “*M.*” *relictus*, *Hipparion tehonense*, *Neohipparion leptode*, *Dinohippus* spp., *Miolabis* sp., *Alforjas* sp., Camelidae (medium-sized sp.), and Antilocapridae (Cosorycinae, gen. and sp. indeterminate). Miocene horses and camels are useful in chronologic correlation because they are abundant in the fossil record and, for most species, their geochronologic ranges are reasonably well defined. This fact allows a chronologic framework to be proposed for the Temblor and Oro Loma Formations based on the perissodactyls and artiodactyls.

INTRODUCTION

The eastern side of the Diablo Range, which forms part of the western border of the San Joaquin Valley of central California, is composed primarily of marine sediments with minor terrestrial sediments ranging in age from the Cretaceous to the Holocene (Arnold and Anderson, 1910; Merriam, 1915c; Bode, 1935b; Woodring et al., 1940; Dibblee, 1975; Bartow, 1996). The first Miocene fossil terrestrial mammals to be recorded from this area were found near the community of Coalinga (Merriam, 1914, 1915c). Merriam (1915a) referred to this locality as the *Merychippus* Zone. Based on further collecting at the site by the California Institute of Technology, Bode (1935a, b) provided a more detailed account of the taxa and stratigraphy of the *Merychippus* Zone. Subsequently, a few other investigators have discussed the fauna from the *Merychippus* Zone (e.g., Stirton, 1940a; Downs, 1961; MacFadden, 1984). Since the initial discoveries, no new significant samples of terrestrial vertebrate fossils have been recovered from the eastern Diablo Range in over 70 years.

During the last several years a program was completed to mitigate the paleontologic impacts

caused by the construction of a new electrical power line (Path 15) between the towns of Los Banos and Coalinga. The Path 15 route traverses Monocline Ridge in a north-south orientation along the east side of the Ciervo Hills, Diablo Range, Fresno County, California. The paleontological impact portion of the project was led by J.D. Stewart and resulted in the discovery of a new fossil locality that yielded highly significant vertebrate fossil specimens. Four additional vertebrate fossil localities near the project area along Monocline Ridge and one locality to the south, near Domengine Creek, were also discovered. Two localities consisted of bone beds with sufficiently high concentrations of fossils to warrant quarrying. The most productive quarry, University of California, Museum of Paleontology locality V-99563, yielded over 1,200 vertebrate fossils along with five Mollusca and one ostracode. Zaborsky (2004) provided a preliminary faunal list for V-99563 based on the identifications by a number of investigators (see Acknowledgments section). Updated faunal lists for all localities are presented in Table 1.

Of the fossil mammals recovered, the perissodactyls are represented by horses and a rhinoceros, while the artiodactyls are represented by camels and a cosorycine antilocaprid. Because Miocene fossil horses are abundant in the fossil record and have reasonably well-defined chronologic ranges, they are particularly useful for biostratigraphic correlation (MacFadden, 1984). Although their taxonomy is not as well defined as that for horses,

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Table 1 Vertebrate faunal lists from new fossil localities, Diablo Range, Fresno County, California. ABBREVIATIONS: indet. = indeterminate; undet. = undetermined

UCMP V-99563, Temblor Formation, Monocline Ridge assemblage (modified after Zaborsky, 2004 [for list of investigators who identified taxa see Acknowledgements section]; also see Tseng et al., 2007; this paper).

Amphibia
Anura, sp. undet
Eureptilia
Ophidia
Colubridae
<i>Masticophis</i> or <i>Coluber</i> sp.
Testudines
Testudinidae
<i>Hesperotestudo</i> sp. of the <i>H. osborniana</i> - <i>orthopyga</i> lineage
Aves
Anseriformes
Anatidae
<i>Branta</i> cf. <i>B. woolfendeni</i>
anatid, sp. undet.
Podicipidae
Passeriformes, sp. undet.
Mammalia
Lagomorpha
Leporidae, sp. undet.
Rodentia, two undet. spp.
Carnivora
Felidae
<i>Pseudaelurus marshi</i>
Mustelidae
<i>Martes</i> cf. <i>M. glarea</i>
mustelid, new gen. and sp.
Amphicyonidae
<i>Amphicyon ingens</i>
Canidae
<i>Microtomarctus conferta</i>
Borophaginae, sp. undet.
Perissodactyla
Equidae
<i>Archaeohippus mourningi</i>
<i>Desmatippus avus</i>
“ <i>Merychippus</i> ” <i>californicus</i>
“ <i>Merychippus</i> ” <i>brevidentus</i>
“ <i>Merychippus</i> ” cf. “ <i>M.</i> ” <i>relictus</i>
Rhinocerotidae
cf. <i>Peraceras</i> sp
Artiodactyla
Antilocapridae
Cosorycinae, gen. and sp. indet.
Camelidae
<i>Miolabis</i> sp.
camelid, sp. undet.
Proboscidea, sp. undet.
LACM 7665, Oro Loma Formation, middle Oro Loma assemblage.
Mammalia
Perissodactyla
Equidae
<i>Hipparion tehonense</i>
LACM 7666, Oro Loma Formation, upper Oro Loma assemblage.
Mammalia
Perissodactyla
Equidae

Table 1 Continued.

<i>Neohipparion leptode</i>
<i>Dinohippus</i> sp.
Artiodactyla
Camelidae
<i>Alforjas</i> sp.
LACM 7664 and 7667, Oro Loma Formation, and
LACM 7668, unnamed nonmarine sediments of Dibblee
(1975), uppermost Oro Loma assemblage.
Mammalia
Perissodactyla
Equidae
<i>Dinohippus</i> spp.

camels can also be useful for biostratigraphic studies. Based primarily on the horses and camels, three North American Land Mammal Ages are represented in the Monocline Ridge area (Barstovian, Clarendonian, and Hemphillian). This report documents the perissodactyl and artiodactyl taxa discovered during the course of this project and provides a preliminary biostratigraphic framework for the fossil localities.

METHODS AND MATERIALS

All specimens from locality V-99563 were deposited in the Museum of Paleontology, University of California, Berkeley. All other specimens were deposited in the Natural History Museum of Los Angeles County. Detailed locality data are on file at these repositories.

Measurements of teeth and appendicular elements were made to the nearest 0.1 mm with a vernier caliper. Equid dental terminology follows Stirton (1941) and MacFadden (1984). All equid teeth were measured following the standards set forth by MacFadden (1984). All other specimens were measured at their greatest dimensions. Upper teeth are designated by uppercase letters and lower teeth by lowercase letters. Metric abbreviations and dental formulae follow standard usage.

All taxonomic identifications were determined by the authors using published accounts and comparative material in the vertebrate paleontological collections of the Natural History Museum of Los Angeles County and the Museum of Paleontology, University of California, Berkeley.

ABBREVIATIONS

A-P	anteroposterior
Ar-Ar	argon-argon
DPOF	dorsal preorbital fossa
K-Ar	potassium-argon
L	left
LACM	Natural History Museum of Los Angeles County, Los Angeles, California
lf	local fauna
Ma	million years before present
O.R.	observed range
R	right
ROC	radius of curvature
s.l.	<i>sensu lato</i>
s.s.	<i>sensu stricto</i>
TR	transverse

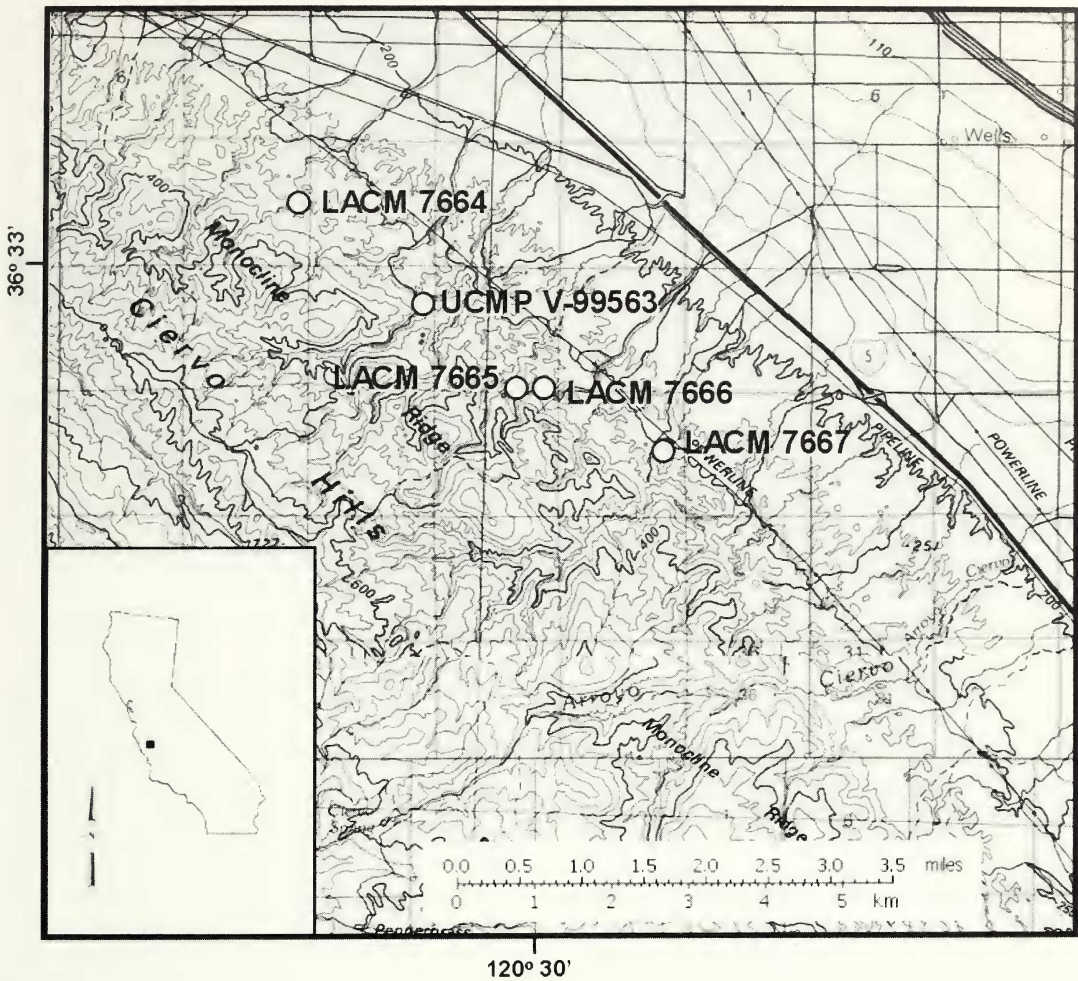


Figure 1 Map showing the geographic location of study area and major vertebrate fossil bearing localities along Monocline Ridge, Diablo Range, Fresno County, California. Base map: U.S. Geological Survey topographic map, 1:100,000 scale

UCMP University of California, Museum of Paleontology, Berkeley, California
UTRL upper tooth row length
V- UCMP vertebrate fossil locality

GEOLOGIC SETTING AND LOCALITIES

The Path 15 route traverses Monocline Ridge along the eastern side of the Diablo Range, between Panoche Creek in the north and Cantua Creek in the south (Figure 1). Bode (1935b) provided a correlation chart of several stratigraphic sections, including the *Merychippus* Zone along Domengine Creek, which is south of Path 15 at the southern end of the Diablo Range. The *Merychippus* Zone is considered to occur in the upper part of the marine Temblor Formation. The Cenozoic sediments in this section were originally assigned to the following, from oldest to youngest (Bode, 1935b): (1)

Temblor Formation (marine), (2) Big Blue Formation (marine), (3) Santa Margarita Formation (marine), (4) Jacalitos Formation (terrestrial), (5) Etchegoin Formation (terrestrial), (6) San Joaquin clay (marine), and (7) Tulare Formation (marine). Subsequently, Dibblee (1975) abandoned the names Jacalitos and Etchegoin formations for the terrestrial sediments overlying the Temblor Formation in this area and referred them to “unnamed nonmarine sediments.” Bartow (1996) provided the most recent geologic map of the Monocline Ridge area, wherein he referred the “unnamed nonmarine sediments” overlying the Temblor Formation to the Oro Loma Formation of Briggs (1953) (Figure 2). The marine Temblor Formation in the study area consists of calcareous cemented to friable, arkosic to lithic sandstone with occasional pebble conglomerate. The overlying nonmarine Oro Loma Formation consists of friable to locally calcareous sandstone (commonly cross-bedded),

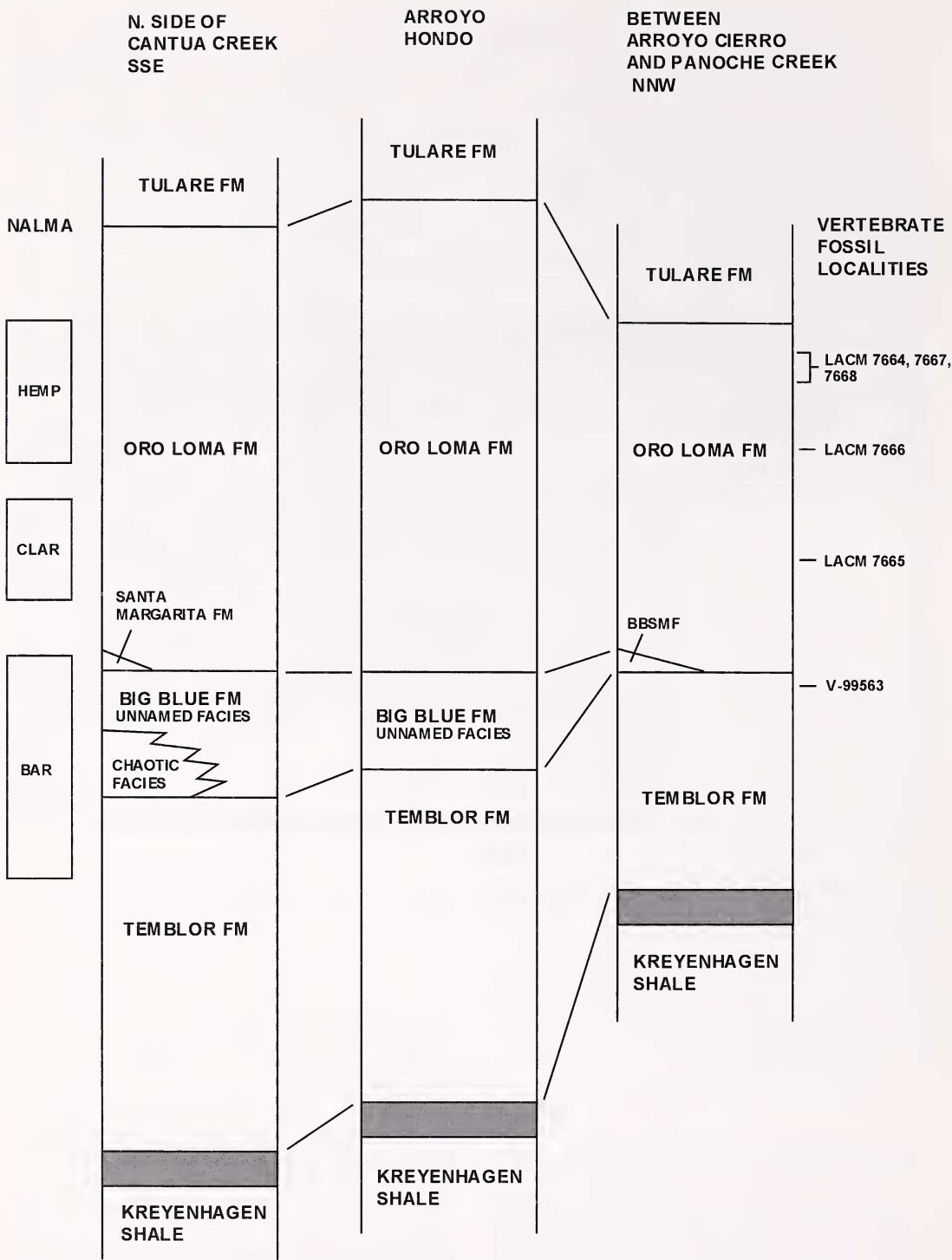


Figure 2 Schematic stratigraphic sections of Monocline Ridge area between Cantua Creek to the south and Panoche Creek to the north, western border of San Joaquin Valley, California, with positions of vertebrate fossil localities. Sections based on geologic map of Bartow (1996), vertical elevation not to scale. ABBREVIATIONS: FM = formation; BAR = Barstovian; CLAR = Clarendonian; BBSMF = Big Blue Formation, Serpentine-mudstone and sandstone facies; HEMP = Hemphillian; NALMA = North American Land Mammal Age



Figure 3 The rhinocerotid cf. *Peraceras* sp. from Temblor Formation, partial left dentary with three partial cheek teeth, UCMP 167070, labial view. Scale = 10 mm

mudstone, claystone, and pebble conglomerate (Bartow, 1996). All of the fossils in the study area were recovered from either the Temblor or Oro Loma Formations.

The localities in the study area have yielded four superposed terrestrial mammal fossil assemblages. The stratigraphically lowest locality, V-99563, occurs on a small hill between Panoche Creek and Arroyo Cierro along Monocline Ridge. The hill consists of landslide debris (Zaborsky, 2004) that came from the upper part of the Temblor Formation. This locality is an extensive bone bed that was quarried during the project and the fauna from it is referred to as the Monocline Ridge assemblage. Locality LACM 7665, which occurs about 1.5 km south of V-99563, is estimated to be about 640 to 740 m stratigraphically above V-99563 in the Oro Loma Formation. The fauna from this locality is referred to as the middle Oro Loma assemblage. Locality LACM 7666, which is also in Oro Loma Formation, occurs about 0.33 km east of LACM 7665 and about 180 m stratigraphically above it. The fauna from LACM 7666 is referred to as the upper Oro Loma assemblage. The other two localities occur to the north (LACM 7664) and south (LACM 7667) of V-99563 along Monocline Ridge. Their relative stratigraphic positions are difficult to assess because of incomplete exposures in the area, but they occur in the uppermost part of the Oro Loma Formation, stratigraphically higher than

all the other localities along Monocline Ridge. The fossils from these localities are referred to the uppermost Oro Loma assemblage. Another locality (LACM 7668) was discovered south of the project area, near the Mack Pumping Station, in the Domingue Creek area of the southern Diablo Range. This locality occurs in the “unnamed nonmarine sediments” of Dibblee (1975), which are a correlative of the Oro Loma Formation along Monocline Ridge. The assemblage from this locality is probably a correlative of the uppermost Oro Loma assemblage. Figure 2 provides three schematic sections of the study area with the relative stratigraphic positions of the vertebrate fossil-bearing localities.

SYSTEMATIC PALEONTOLOGY

Perissodactyla Owen, 1848

Rhinocerotidae Gray, 1821

Peraceras Cope, 1880b

cf. *Peraceras* sp.

Figure 3

REFERRED SPECIMEN. From locality V-99563: partial left dentary with three partial cheek teeth, UCMP 167070.

DESCRIPTION. The partial dentary contains three well-worn partial lower cheek teeth. The anterior and posterior cheek teeth are represented by small portions of their occlusal surfaces and their anterior and posterior roots, respectively.

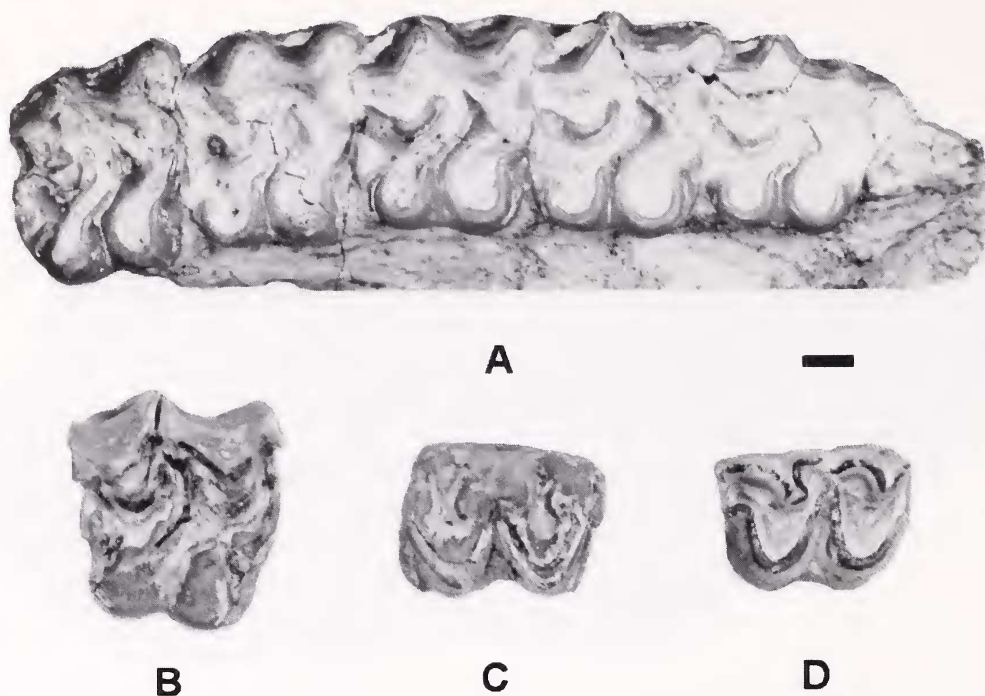


Figure 4 *Desmatippus avus* from Temblor Formation. A, partial maxilla with partial RP1, RP2–M2, UCMP 166555; B, RM1 or 2, UCMP 166863; C, Lp3 or 4, UCMP 166883; D, Rm1 or 2, UCMP 166697. All occlusal views. Scale = 5 mm

These two partial teeth are missing the lingual and labial enamel surfaces. The middle cheek tooth is missing the lingual enamel surface, whereas the labial enamel is partially preserved and exhibits a distinct cingulum. It is difficult to determine which three lower teeth these represent because the lower premolars of Rhinocerotidae are molariform. However, the occlusal wear pattern of the middle tooth suggests that it may represent p4 or m1. The A–P dimension of the middle tooth is estimated at about 50 mm.

Although well worn, the middle tooth appears to be lower crowned than those of *Teleoceras* Hatcher, 1894. *Peraceras* has strong labial and lingual cingula present on all lower cheek teeth (Prothero, 2005). Distinct labial cingula are also present on the lower cheek teeth of *Aphelops* Cope, 1874, but the lingual cingula are not developed as in *Peraceras*. Because the lingual enamel surfaces are missing in UCMP 167070, generic assignment of the specimen based on the presence or absence of lingual cingula cannot be determined. The size of the teeth in UCMP 167070 appear too large to represent the Barstovian *Aphelops megalodus* (Cope, 1873), *Peraceras hessei* Prothero and Manning, 1987, or *Peraceras profectum* (Matthew, 1899), but are comparable in size to those of the Barstovian *Peraceras superciliosum* Cope, 1880b, and may represent this species (D.R. Prothero, personal

communication, 2007). However, due to the poor preservation of UCMP 167070, it is only tentatively referred to *Peraceras*.

Equidae Gray, 1821

Desmatippus Scott, 1893

Desmatippus avus Marsh, 1874

Figure 4, Table 2

REFERRED SPECIMENS. From locality V-99563: partial left maxilla with P1–M2, UCMP 166555; RM1 or 2, UCMP 166863; Lp3 or 4, UCMP 166883; Rm1 or 2, UCMP 166697.

DESCRIPTION. The upper teeth are characterized by the following: (1) moderately large size, as compared with other parahippine horses; (2) moderately thick cement within the fossettes and lophs, and a thin coat or none on the external surfaces of the teeth; (3) simple crochet present in early wear extending to near the base of the protoloph (the crochet is worn away in late wear); (4) in early wear, protocone separated from the protoconule by a distinct constriction; (5) plications present on the metaloph during early wear; (6) metaloph connected to the ectoloph; (7) hypocone as large or nearly as large as the protocone; (8) large triangular hypostyle; and (9) well-developed anterior cingulum extending to the anterior labial aspect of the protocone. The lower teeth are of typical parahippine morphol-

Table 2 Measurements (in mm) of *Desmatippus avus* from Temblor Formation. ABBREVIATION: a = approximate

UCMP specimen number	Position/dimension	Measurement
166555	P1 A-P	12.5a
	TR	—
	P2 A-P	22.4a
	TR	21.2
	P3 A-P	21.4
	TR	24.0
	P4 A-P	21.1
	TR	23.5
	M1 A-P	21.4
	TR	23.5
166863	M2 A-P	20.6a
	TR	23.5
	P2-4 A-P	60.7a
	M1-M2	40.6a
	RM1 or 2 A-P	22.0
166883	TR	24.3
	Lp3 or 4 A-P	19.5
166697	TR	16.3
	Rm1 or 2 A-P	17.8
	TR	13.7

ogy. The lower premolar has much better developed anterior and posterior cingulids than the lower molar and it appears that the cingulids may have extended around the external bases of the protoconid and hypoconid, respectively. In the lower molar the anterior and posterior cingulids are much weaker, although a cingulid is present between the protoconid and hypoconid. A moderately thick covering of cement is present on the lower teeth.

DISCUSSION. In size and occlusal morphology, the teeth from UCMP V-99563 are indistinguishable from those of *Desmatippus avus* from the *Merychippus* Zone from the North Coalinga area of California and the Mascall Fauna of Oregon, except that the upper molars lack internal cingula and the one lower molar lacks an external cingulid. Other investigators have long noted that *Desmatippus crenidens* Scott, 1893, from Deep River, Montana, was very similar to *D. avus* (Gidley, 1907; Merriam and Sinclair, 1907; Downs, 1956). Downs (1956) noted that except for the lack of an internal cingulum on the upper cheek teeth, lack of an external cingulid on the lower cheek teeth, less cement, and no ribs, all other characteristics of the cheek teeth are as those in the type of *D. crenidens*. The teeth from UCMP V-99563 differ from those of *D. crenidens* by having thicker cement and better-developed parastyles and mesostyles. The material of *Desmatippus* from the *Merychippus* Zone was originally referred to *Parahippus brevidens* (Marsh, 1874), which is now regarded as a junior synonym of *D. avus* (Bode, 1935a; Downs, 1951, 1956; Tedford et al.,

1987, 2004). In the type of *P. brevidens* and referred specimens, an internal cingulum is lacking on the upper molars (Osborn, 1918; Downs, 1956). Thus the presence or absence of internal and external cingula and cingulids on the upper and lower cheek teeth, respectively, does not seem to be a reliable diagnostic character to separate these species. Needless to say, the parahippines are in desperate need of revision. Based on size and all other dental morphology, the parahippine teeth from UCMP V-99563 are regarded as conspecific with the parahippine material from North Coalinga and Mascall, and are referred to *D. avus*.

Archaeohippus *Gidley, 1906*
Archaeohippus *mourningi* Merriam, 1913
Figure 5, Table 3

REFERRED SPECIMENS. From locality V-99563: partial left maxilla with P3-4, UCMP 166508; LP3 or 4, UCMP 166510; RM1 or 2, UCMP 166639; Lp3 or 4, UCMP 166504.

DESCRIPTION. The upper cheek teeth are characterized by the following: (1) moderately large size, as compared with other species of *Archaeohippus*; (2) moderate hypsodonty (estimated mesostyle crown height in a barely worn tooth is between 9 and 10 mm); (3) crochet absent; (4) metaloph lacking plications; (5) hypostyle large with deep pit in early wear, triangular in late wear; (6) hypocone well developed, as large as protocone; (7) internal cingulum lacking; and (8) no cement. The lower cheek tooth has a weakly developed external cingulid and lacks cement.

DISCUSSION. The *Archaeohippus* teeth from UCMP V-99563 are referred to *Archaeohippus mourningi* because they possess all the diagnostic characters of this species (Merriam, 1913; Osborn, 1918; Downs, 1956) and are indistinguishable from those referred to *A. mourningi* from the Barstow Formation, the Caliente Formation, and the *Merychippus* Zone of North Coalinga, California.

“*Merychippus*” s.l. Leidy, 1857
“*Merychippus*” *californicus* Merriam 1915a
Figures 6-9, Tables 4-5

REFERRED SPECIMENS. From locality V-99563: partial skull with RP2-M3 and LP2-M3, UCMP 166252; partial left maxilla with partial M1 and M2-3, UCMP 166271; partial right maxilla with M1-2, UCMP 166276; partial maxilla with dP2-4, UCMP 166262; dRP4, UCMP 166231; dLP3, UCMP 166295; three associated cheek teeth, RM2 and LM1-2, UCMP 166224; RP2s, UCMP 166213, 166214, 166225, 166238, 166310, 166483; LP2s, UCMP 166223, 166229, 166245, 166289, 166318, 166338, 166471; RP3s, UCMP 166234, 166241,

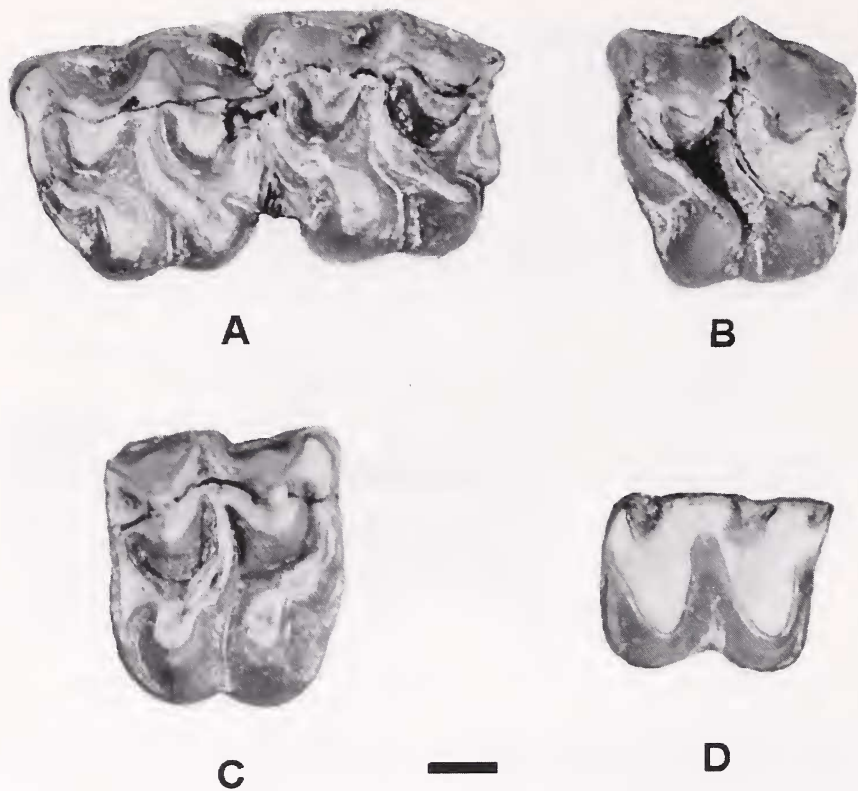


Figure 5 *Archaeobippus mourningi* from Temblor Formation. A, partial maxilla with LP3-4, UCMP 166508; B, LP3, UCMP 166510; C, RM1 or 2, UCMP 166639; D, lower left cheek tooth, UCMP 166504. All occlusal views. Scale = 5 mm

166267, 166280, 166288, 166344, 166414; LP3s, UCMP 166305, 166319, 166463; RP4s, UCMP 166215, 166239, 166242; LP4s, UCMP 166220, 166228, 166253, 166258; RM1s, UCMP 166226, 166237, 166248, 166291, 166294, 166396, 166399; LM1s, UCMP 166232, 166244, 166247, 166256, 166277, 166301, 166307, 166327, 166345, 166419; RM2s, UCMP 166408, 166438; LM2s, UCMP 166230, 166240, 166265, 166329, 166339,

166368; RM3s, UCMP 166222, 166233, 166251, 166252, 166279, 166328; LM3s, UCMP 166261, 166379; left upper molar, UCMP 166243; partial right dentary with partial dp2-4 and m1-2, UCMP 166446; partial right dentary with i1 and p2-m3, UCMP 166917; partial right dentary with broken p2 and p3-m3, UCMP 166445; partial right dentary with partial dp2 and m1, 166299; partial right dentary with partial dp3 and dp4, UCMP 166455; partial right dentary with dp4-m1, UCMP 166441; partial right dentary with p2-m3, UCMP 166218; partial right dentary with p3 or 4, UCMP 166486; partial right dentary with m3, UCMP 166227; partial right dentary with m1-3, UCMP 166260; partial right dentary with dp2-3, UCMP 166250; Rm1, UCMP 166480; partial left dentary with dp2, UCMP 166469; partial left dentary with dp2 and partial dp3, UCMP 166216; partial left dentary with p2, UCMP 166466; partial left dentary with p2-m3, 166315; partial left dentary with partial m1-2 and m3, UCMP 166306.

Table 3 Measurements (in mm) of *Archaeobippus mourningi* from Temblor Formation

UCMP specimen number	Position/dimension	Measurement
166508	LP3 A-P	14.4
	TR	13.9
	LP4 A-P	15.0
116510	TR	14.2
	LP3 or 4 A-P	14.7
	TR	16.6
166639	RM1 or 2 A-P	13.4
	TR	15.9
166504	Lower cheek tooth A-P	13.5
	TR	11.0

DESCRIPTION. The sample includes a partial skull, three partial maxillae, 16 partial dentaries, and numerous isolated cheek teeth. All positions and stages of wear are represented in the cheek teeth including 12 specimens possessing decidu-

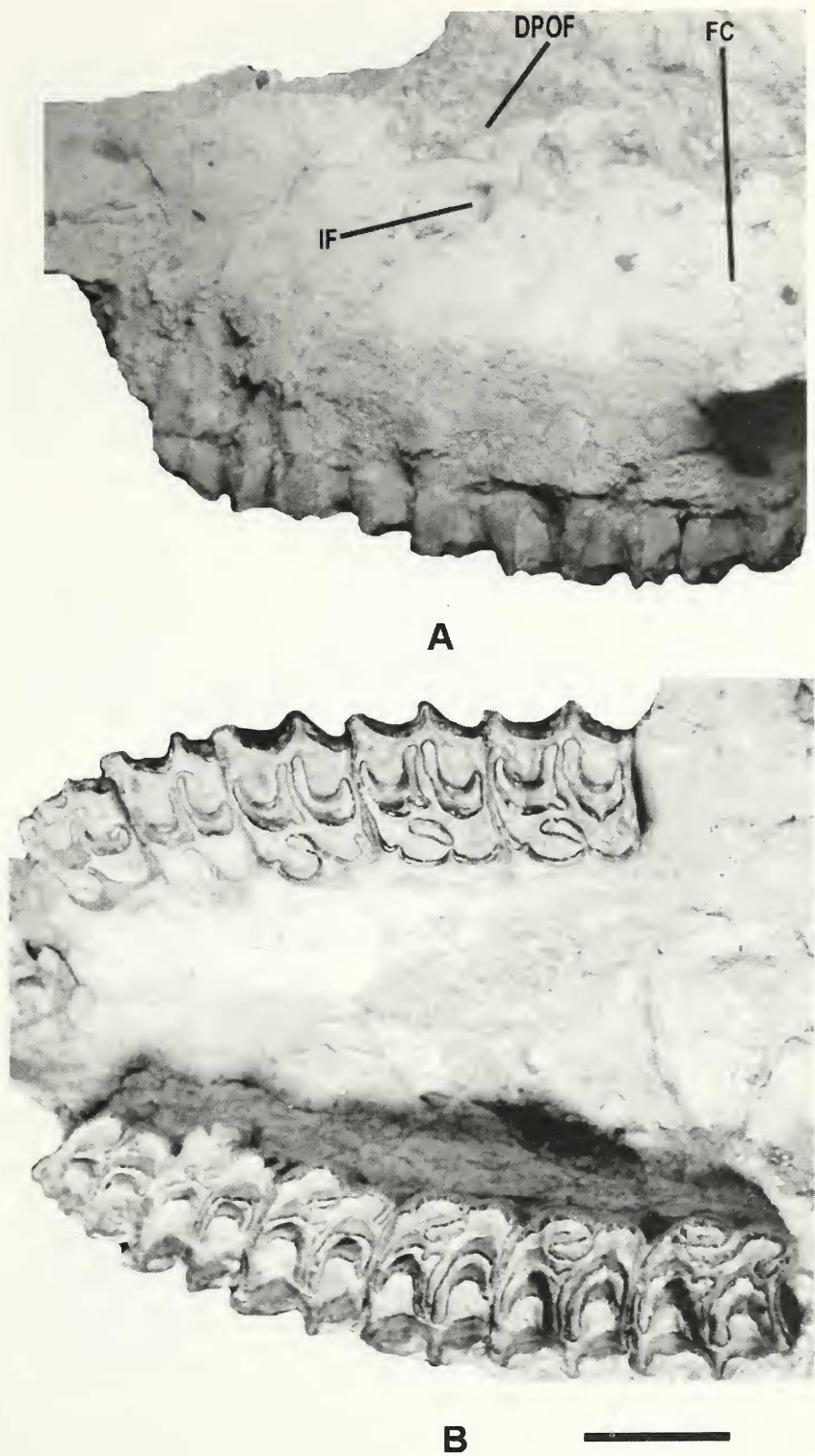


Figure 6 “*Merychippus*” *californicus* from Temblor Formation. A–B, partial skull with LP2–M2 and RP2–M3, UCMP 166252: A, left side of partial skull showing position of infraorbital foramen (IF), ventral border of anterior portion of dorsal preorbital fossa (DPOF), and dorsoventral depression of bone above facial crest (FC) that appears to represent the anterior portion of a shallow malar fossa and not a result of compression or distortion during preservation; B, LP2–M2 and RP2–M3, occlusal view. Scale = 20 mm

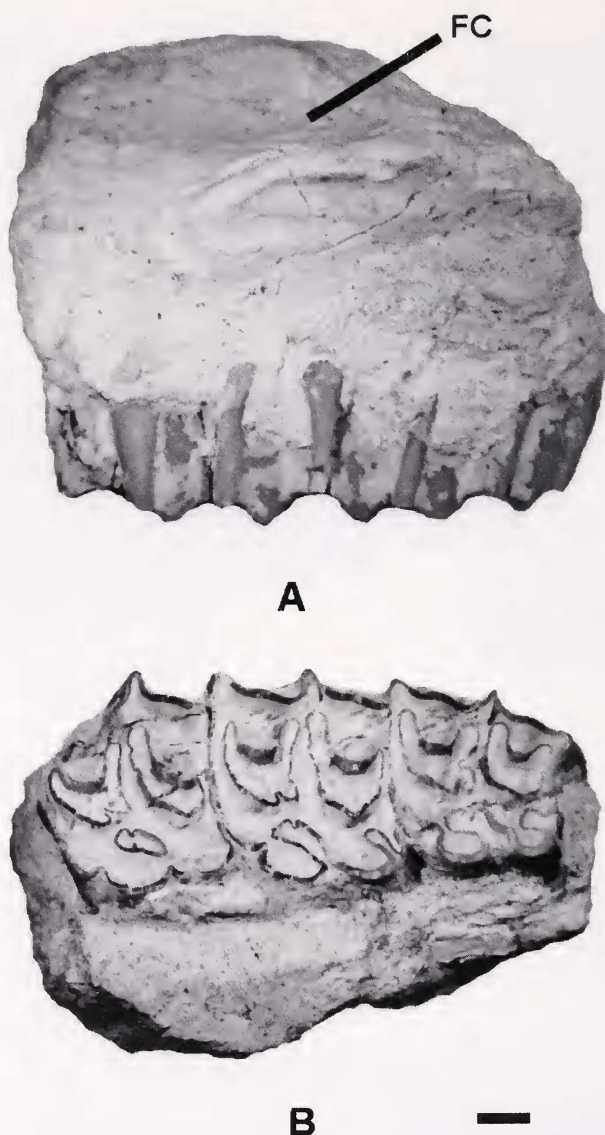


Figure 7 "*Merychippus*" *californicus* from Temblor Formation. A-B, partial left maxilla with partial M1 and M2-3, UCMP 166271: A, labial view; B, occlusal view. Scale = 5 mm. Note: dorsoventral depression of bone above facial crest (FC) that appears to represent the anterior portion of a shallow malar fossa and not a result of compression or distortion during preservation

ous cheek teeth. One well-known characteristic of horse upper and lower cheek teeth is that they vary in length and width from the crown to the base (e.g., Downs, 1961; Eisenmann et al., 1988). At unworn or early wear stages, the A-P dimension at the occlusal surface is greater than the A-P dimension at the base of the crown, which results in significantly larger A-P measurements for these teeth in comparison to teeth that are in moderate to late wear. Conversely at unworn or early wear stages, the TR dimension is narrower at the occlusal surface than at the base of the crown, so that the TR measurement increases significantly with wear. This can result in higher

coefficients of variation in the dental statistics, especially in P3, M1, and m1, where the samples include very worn teeth and/or unworn teeth.

The sample of permanent upper cheek teeth is characterized by the following: (1) moderately complex occlusal fossette enamel plications in early wear that become progressively less complex with wear, so that when they are about 50% or more worn the occlusal pattern becomes simple; (2) prominent and relatively persistent plis protoconule present on P3-M3; (3) P3-M2 protocones isolated from the protoloph until the teeth are worn by 50% or more; (4) oval P3-M3 occlusal protocone outlines with distinct spurs in early

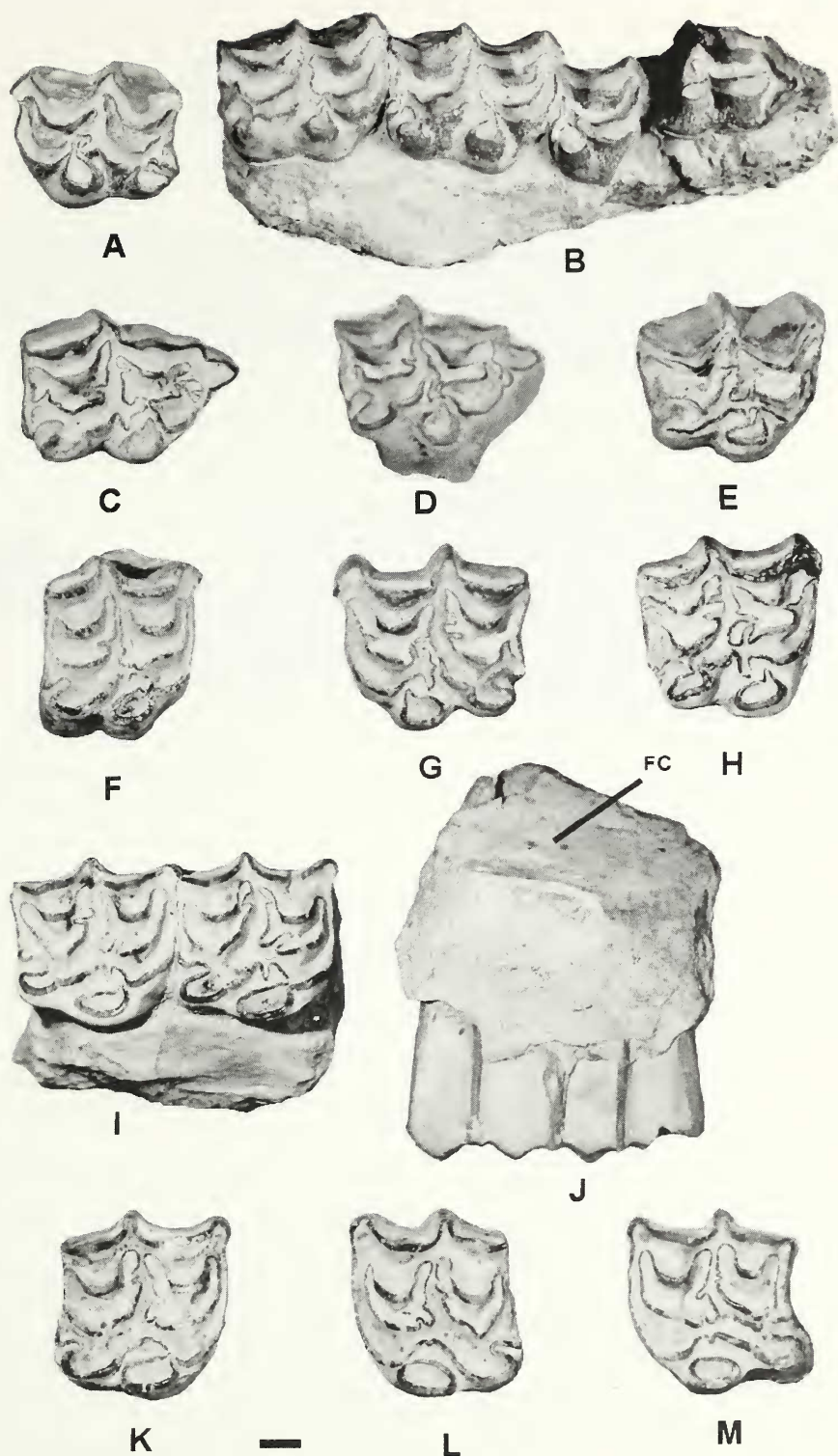


Figure 8 "*Merychippus*" *californicus* from Temblor Formation. A, LdP4, UCMP 166295; B, partial right maxilla with dp2-dp4, 166262; C, RP2, UCMP 166214; D, RP2, UCMP 166483; E, RP3, UCMP 166234; F, RP3, UCMP 166267; G, LP4, UCMP 166258; H, RP4, UCMP 166215; I-J, partial maxilla with M1-2, UCMP 166276; K, RM1, UCMP 166248; L, LM2, UCMP 166247; M, RM3, UCMP 166261. A-I and K-M occlusal views, J labial view. Scale = 5 mm. Note: dorsoventral depression of bone above facial crest (FC); depression does not appear to be due to compression or distortion during preservation, but appears to represent the anterior portion of a shallow malar fossa

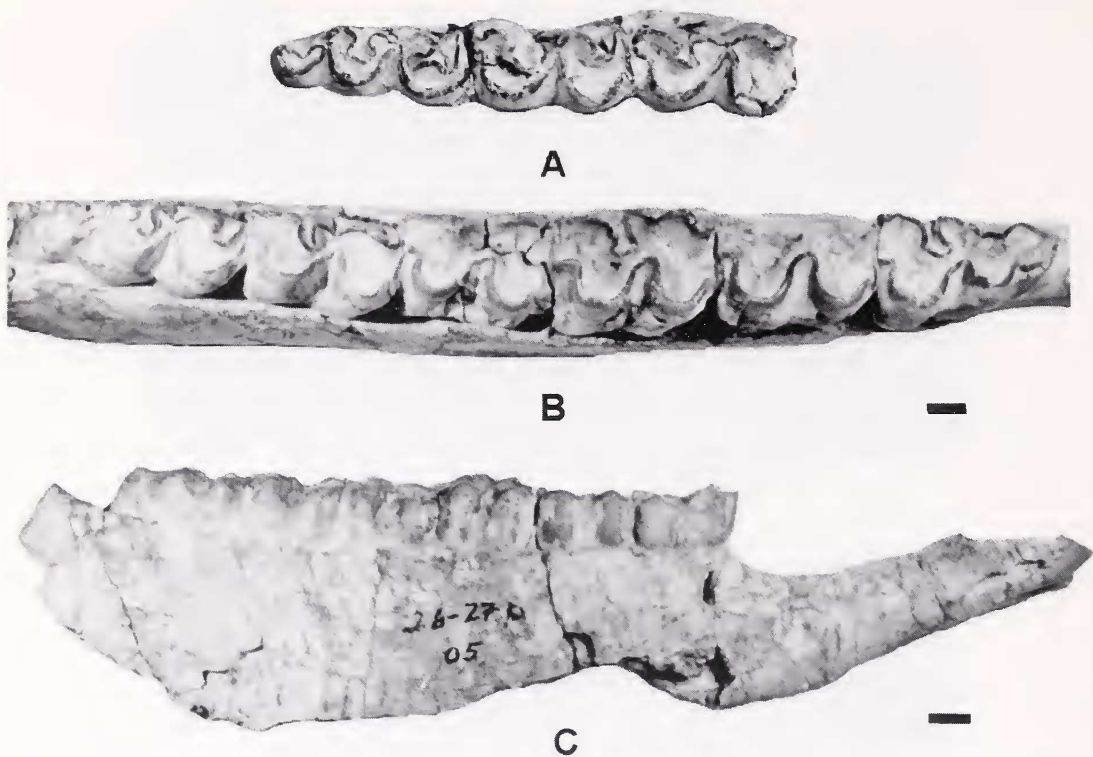


Figure 9 “*Merychippus*” *californicus* from Temblor Formation. A, partial right dentary with m1–3, UCMP 166260; B–C, partial right dentary with p2–m3, UCMP 166917: B, occlusal view; C, lateral view. Upper scale for A–B = 5 mm, lower scale for C = 10 mm

Table 4 Measurements (in mm) of upper dentition of “*Merychippus*” *californicus* from Temblor Formation. ABBREVIATIONS: N = number of specimens; SD = standard deviation; O.R. = observed range; CV = coefficient of variation; a = approximate

Position/ dimension	N	Mean	SD	O.R.	CV
dp2 A-P	1	27.8a	–	–	–
TR	1	12.8a	–	–	–
dp3 A-P	2	21.2	–	20.8–21.5	–
TR	2	15.7	–	15.5–15.9	–
dp4 A-P	2	20.45	–	20.4–20.5	–
TR	2	17.1	–	15.5–18.7	–
P2 A-P	9	21.5	1.41	18.5–22.8	6.6
TR	10	17.1	1.48	15.1–19.1	8.7
P3 A-P	6	19.5	1.56	17.6–21.4	8.0
TR	5	19.2	1.99	17.3–22.5	10.4
P4 A-P	15	20.2	1.17	18.0–22.2	5.8
TR	15	19.8	1.35	18.0–22.5	6.8
M1 A-P	11	17.9	1.51	16.4–21.5	8.4
TR	12	20.0	1.37	18.1–21.9	6.9
M2 A-P	12	19.0	1.41	16.9–20.9	7.4
TR	12	19.3	0.98	16.8–20.5	5.0
M3 A-P	10	18.4	1.03	16.7–20.5	5.6
TR	10	17.4	1.39	15.5–19.3	8.0
P2–4 A-P	2	58.05	–	58.0–58.1	–
M1–3 A-P	2	52.3	–	52.0–52.5	–
UTRL	1	108.6	–	–	–

Table 5 Measurements (in mm) of lower dentition of “*Merychippus*” *californicus* from Temblor Formation. ABBREVIATIONS: N = number of specimens; SD = standard deviation; O.R. = observed range; CV = coefficient of variation

Position/ dimension	N	Mean	SD	O.R.	CV
dp2 A-P	2	20.7	–	20.0–21.4	–
TR	1	8.6	–	–	–
dp3 A-P	3	20.2	–	19.6–20.6	–
TR	4	9.2	–	8.6–10.5	–
dp4 A-P	2	20.2	–	19.4–21.0	–
TR	2	8.85	–	8.8–8.9	–
p2 A-P	2	19.5	–	18.4–20.5	–
TR	4	10.2	–	9.8–10.9	–
p3 A-P	3	17.7	–	17.1–18.5	–
TR	2	11.6	–	11.1–12.2	–
p4 A-P	3	17.9	–	17.2–18.5	–
TR	3	11.6	–	11.0–12.2	–
m1 A-P	6	18.5	2.23	16.4–22.2	12.1
TR	6	9.3	1.07	8.1–11.0	11.5
m2 A-P	5	17.0	0.55	16.4–17.6	3.2
TR	5	9.2	0.45	8.5–11.0	5.0
m3 A-P	7	21.0	0.99	19.6–22.0	4.7
TR	7	8.4	0.72	7.0–9.2	8.6
p2–4 A-P	2	57.6	–	56.7–58.4	–
m1–3 A-P	5	55.3	0.65	54.7–56.0	1.0
p2–m3 A-P	2	111.6	–	111.2–111.9	–
I3–p2 diastema	1	43.7	–	–	–

wear, becoming increasingly more elongated anteroposteriorly in moderate to late wear; (5) P3–M2 hypocones attached to metalophs in early wear, with slightly elongated oval occlusal outlines in early wear that become more elongated anteroposteriorly with increased wear; (6) P2–M3 cement moderately heavy; (7) unworn P3–4 mesostylar crown height averaging about 35 mm, whereas unworn M1–2 mesostylar crown height averages about 32 mm; and (8) moderately small size, as compared with other Barstovian “merychippine” grade horses (based on dimensions of individual teeth in all wear stages and a single UTRL of 108.6 mm for one specimen in moderate late wear).

The deciduous upper cheek teeth are characterized by having the following: (1) moderate cement covering, especially prominent in internal valleys; (2) cylindrical protocones and hypocones, with hypocones oriented in an A–P direction; and (3) relatively strong hypsodonty (moderately worn dP3 crown height = 15.1 mm).

The occlusal patterns of the permanent lower cheek teeth are typical of “merychippine” grade horses. The unworn mesostylid crown height of m1–2 averages about 32 mm. Prominent protostylids are present on m1–3. The cement is moderately heavy. The prefossettid and postfossettid occlusal patterns are simple and are commonly worn away when the teeth are in early late wear. In size, the tooth dimensions are moderately small as compared with other Barstovian “merychippine” grade horses (mean p2–m3 length = 111.6). The deciduous lower premolars possess moderately heavy cement along the labial surfaces and are relatively high-crowned; mesostylid crown height in early to early moderate wear equals 8.5 to 9.0 mm.

DISCUSSION. The type species of *Merychippus* is *Merychippus insignis* Leidy, 1857, from the Bijou Hills, South Dakota. For many years after Leidy’s description, investigators assigned many mesodont to moderately hypsodont middle Miocene equids to *Merychippus* (e.g., Gidley, 1907; Merriam, 1915a; Osborn, 1918; Stirton, 1940a). Osborn (1918) typified this taxonomic scheme by classifying these middle Miocene equids as “merychippine grade” horses. More recent studies have demonstrated that most of the species previously assigned to *Merychippus* actually belong to other genera (e.g., Skinner et al., 1977; Bernor et al., 1980; MacFadden, 1984; Hulbert, 1989; Hulbert and MacFadden, 1991; Kelly, 1995, 1998; Woodburne, 2003; Pagnac, 2006). *Merychippus* s.s., as typified by *M. insignis*, is distinguished by a specific suite of dental, cranial, and facial fossa characters (Skinner and Taylor, 1967; Woodburne, 2003). In particular, knowledge of the facial morphology (DPOF and the presence or absence of a malar fossa) is required for proper generic assignment. In some species originally assigned to *Merychippus*, cranial material is either

unknown or insufficient to determine if they belong to *Merychippus* s.s. or another genus. Following most recent investigators, we refer these species to “*Merychippus*” s.l., indicating that their generic assignment is uncertain.

In size, crown height, and cheek teeth occlusal morphology, the sample from UCMP V-99563 fits well within the variation observed in the sample of “*Merychippus*” *californicus* from the Temblor Formation of North Coalinga, California (Merriam, 1915a; Bode, 1935a; Downs, 1961). The distinctive upper deciduous premolar morphology is also indistinguishable from that of the North Coalinga sample of “*M.*” *californicus* (Bode, 1935a). This sample can be confidently assigned to “*M.*” *californicus*.

Previously, there were no known specimens of “*M.*” *californicus* that preserved any portion of the facial morphology. In the partial skull (UCMP 166252: Figure 6), portions of the right and left side of the face are preserved that include the anterior portions of the facial crests above the M1–2s posteriorly, to about 11–16 mm above the infraorbital foramina dorsally, and to the buccinator fossae anteriorly. Two other specimens, a partial right maxilla with M1–2 (UCMP 166276: Figure 8) and a partial left maxilla with M1–3 (UCMP 166271: Figure 7), preserve anterior portions of the facial crests. In all specimens, there does not appear to be any significant crushing or distortion of these regions. As shown in Figure 6, the infraorbital foramen lies above the anterior half of P4. The bone along the dorsal aspect of the anterior portion of the facial crest is dorsoventrally compressed, very similar to that of *Acritohippus* Kelly, 1995 (Quinn, 1984; Kelly, 1998), and not rounded or inflated as that of the protohippines *Scaphohippus sumani* (Merriam, 1915b) and *Scaphohippus intermontanus* (Merriam, 1915b), *Protohippus* Leidy, 1858, and *Calippus* Matthew and Stirton, 1930 (Hulbert, 1988; Pagnac, 2006), *Merychippus insignis* (Quinn, 1984; Woodburne, 2003), and the hipparionines (Webb, 1969; Bernor et al., 1980; MacFadden, 1984; Quinn, 1984; Kelly, 1995, 1998; Woodburne, 1996, 2003). In *Acritohippus*, the facial crest is dorsoventrally compressed because it possesses a shallow malar fossa that extends from just above M2 along the dorsal aspect of the facial crest posteriorly to the malar. Also in *Acritohippus*, the anterior portion of DPOF above the infraorbital foramen has an indistinct ventral border that consists of a low rounded edge leading to the anterior shallow depression of the DPOF. The dorsoventral compression of the dorsal aspect of the facial crests above M1–2 in the partial skull and partial maxillae of “*M.*” *californicus* appears to be real and not a result of crushing or distortion during preservation, suggesting that the facial morphology of “*M.*” *californicus* may include a shallow malar fossa like that of *Acritohippus*. Furthermore,

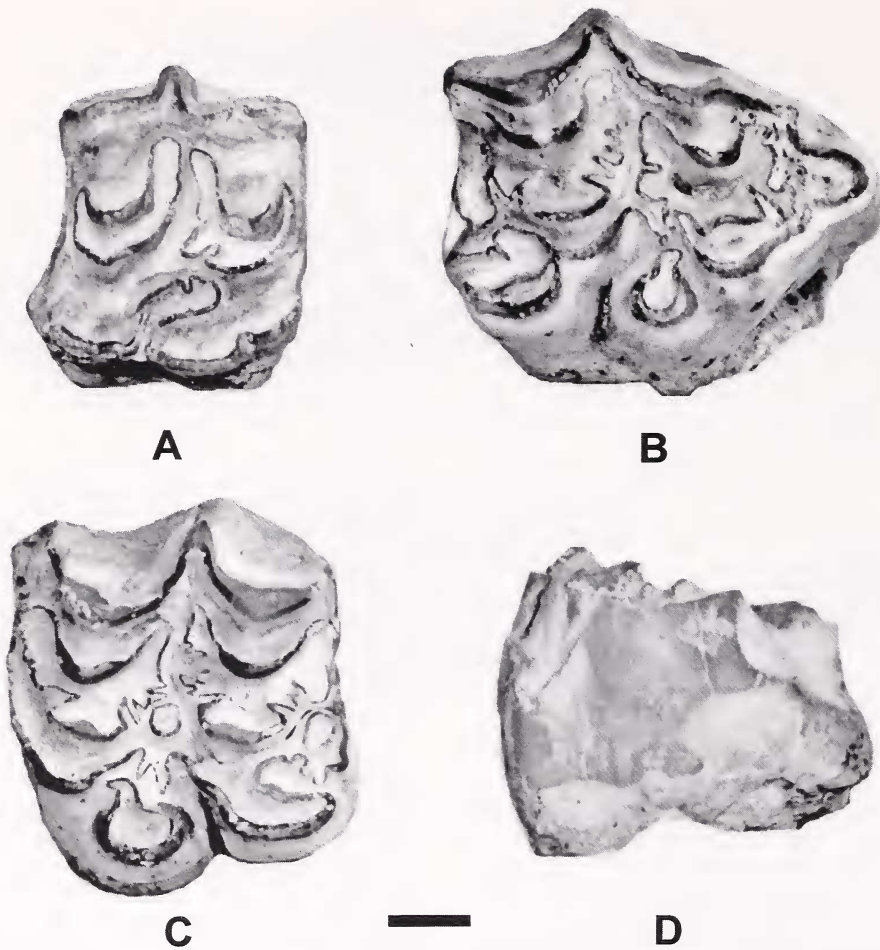


Figure 10 "*Merychippus*" cf. "*M.*" *relictus* and "*Merychippus*" *brevidontus* from Temblor Formation. A, "*M.*" cf. "*M.*" *relictus*, RM1, UCMP 166272; B–D, "*M.*" *brevidontus*: B, RP2, UCMP 166213; C, LP3, UCMP 166212; D, LP3, UCMP 166212. A–C occlusal views, D anterior view. Scale = 5 mm

shallow depressions are preserved on both sides of the skull above the infraorbital foramina (about 16 mm on the left and 11 mm on the right). A very low, rounded rim of bone occurs just above the infraorbital foramen where this depression drops off from the facial surface. These depressions appear to represent the anterior ventral portions of the DPOFs, indicating the anterior ventral border of the DPOF in "*M.*" *californicus* is also like that of *Acritohippus*. Previous investigators have noted similarities in the dental morphology of "*M.*" *californicus* and *Acritohippus isonesus* (Cope, 1889) of the Mascall Fauna of Oregon and suggested a close phylogenetic relationship between the species (Bode, 1935a; Stirton, 1940a; Downs, 1956, 1961; Shorwell, 1968). Although the evidence is based on only three specimens, it strongly suggests that "*M.*" *californicus* possesses a facial morphology similar to species of *Acritohippus* and may actually belong in this

genus. However, until more complete material preserving the facial morphology is available, the sample from the Temblor Formation is referred to "*M.*" *californicus*.

"Merychippus" brevidontus Bode, 1935a

Figure 10, Table 6

REFERRED SPECIMENS. From locality V-99563: RP2s, UCMP 166213, 166255, 166257; RP4, UCMP 166437; RM1 or 2, UCMP 166449; LdP2, UCMP 166325; LP3 or 4, UCMP 166212.

DISCUSSION. Several upper cheek teeth possess very complex occlusal enamel patterns and low crown height (Figure 10). For example, the mesostylar crown heights of UCMP 166257 (unworn P2) and UCMP 166255 (P2 in very early wear) are 21 and 19.3 mm, respectively, while the crown height of UCMP 166437 (P4 or M1 in early wear) is 20.3 mm. In size, crown height, and occlusal morphology, they are

Table 6 Measurements (in mm) of teeth of “*Merychippus*” *brevidentus* and “*Merychippus*” cf. “*M.*” *relictus* from Temblor Formation

Taxon	UCMP specimen number	Position/ dimension	Measure- ment
“ <i>M.</i> ” <i>brevidentus</i>	166213	RP2 A-P	22.7
		TR	17.4
“ <i>M.</i> ” <i>brevidentus</i>	166257	RP2 A-P	23.6
		TR	17.5
“ <i>M.</i> ” <i>brevidentus</i>	166255	RP2 A-P	22.8
		TR	17.6
“ <i>M.</i> ” <i>brevidentus</i>	166437	RP4 or M1 A-P	19.5
		TR	20.3
“ <i>M.</i> ” <i>brevidentus</i>	166449	RM1 or 2	17.3
		TR	19.9
“ <i>M.</i> ” <i>brevidentus</i>	166212	LP3 or 4 A-P	18.6
		TR	19.2
“ <i>M.</i> ” cf. “ <i>M.</i> ” <i>relictus</i>	166272	RM1 A-P	14.6
		TR	18.1

indistinguishable from those assigned to “*M.*” *brevidentus* from the Temblor Formation of North Coalinga (Bode, 1935a).

“*Merychippus*” cf. “*M.*” *relictus* Cope, 1889
Figure 10, Table 6

REFERRED SPECIMEN. From locality V-99563: RM1, 166272.

DISCUSSION. A single specimen, a moderately well worn RM1 (UCMP 166272), is distinct from all other specimens. It differs from those assigned to “*M.*” *brevidentus* by its smaller size and much less complex occlusal enamel pattern. It differs from the sample of “*M.*” *californicus* by its much smaller size and thinner cement. In size and occlusal morphology, it is most similar to “*Merychippus*” *relictus* from Oregon (Downs, 1956; Shotwell, 1968). It is possible that this specimen is just an aberrant representative of “*M.*” *californicus*, but the significantly smaller size suggests that it may represent the rare species “*M.*” *relictus*. Therefore, until additional material is available, this specimen is assigned to “*M.*” cf. “*M.*” *relictus*.

Hipparion de Christol, 1832

Hipparion tehonense Merriam, 1916

Figure 11, Table 7

REFERRED SPECIMEN. From locality LACM 7665: associated partial LM1–2 and M3, LACM 152701.

DESCRIPTION. The horse material from locality LACM 7665 consists of a partial M1, partial M2, and M3 (LACM 152701) in moderate to early late wear. The partial M1 is missing the labial portion, including part of the protoloph, the protocone, and part of the hypocone. The M2 is missing the lingual half of the protocone and a

small portion of the lingual aspect of the hypocone. The M3 is complete. The upper molars are characterized by the following: (1) moderately small size, as compared with other middle to late Miocene hipparionines; (2) relatively complex fossette occlusal enamel borders (well-developed pli prefossette, pli protoconule, pli postfossette, pli hypostyle, and multiple additional plications on posterior border of prefossette and anterior border of postfossette); (3) slightly anteroposteriorly elongated oval-shaped protocones with rounded borders; (4) protocones isolated from the protoloph; (5) single, small but distinct plis caballin; (6) distinct hypoconal grooves; (7) very little curvature (ROC = 69–78 mm); and (8) moderately heavy cement. The mesostylar heights of the teeth are 22.1 mm for M1, 26.2 mm for M2, and 28.4 mm for M3. Considering their degree of wear, the teeth are relatively hypsodont.

DISCUSSION. *Hipparion tehonense* has been well described (e.g., Merriam, 1916; Stirton, 1939, 1940b; Drescher, 1941; MacFadden, 1984). In size and occlusal morphology, the teeth from locality LACM 7665 are indistinguishable from those of *H. tehonense*. They differ from those of *Neohipparion* Gidley, 1903, and advanced species of *Cormohipparion* Skinner and MacFadden, 1977, by having smaller, oval protocones with rounded borders (not anteroposteriorly elongated with angular borders). They further differ from *Cormohipparion occidentale* s.l. (Leidy, 1856) and *Neohipparion eurystyle* (Cope, 1893) by having less complicated occlusal enamel patterns (Hulbert, 1987; Woodburne, 2007). They differ from those of *Hipparion forcei* Richey, 1948, by their smaller size and, considering their wear stage, less hypsodonty.

Neohipparion Gidley, 1903

Neohipparion leptode Merriam, 1915b

Figure 12, Table 8

REFERRED SPECIMENS. From locality LACM 7666: RP2, LACM 152702; RM2–3, LACM 152704; Rp3 or 4, LACM 152705; Rm1 or 2, LACM 152706.

DISCUSSION. The hipparionine upper teeth from LACM 7666 are moderately hypsodont (considering, even in moderate wear, the mesostylar crown height for M2–3 = 41–43 mm) with very elongated protocones (ratio of protocone length to width = 2.2 for P2 and 2.6–2.7 for M2–3) that remain isolated until very late wear, which are typical of species of *Neohipparion*. In size and occlusal morphology the cheek teeth are indistinguishable from those of *Neohipparion leptode*. They differ from those of *Neohipparion trampasense* (Edwards, 1982) by their larger size, relatively longer protocones, less angular anterior and posterior borders of the protocones, and slightly less plicated fossette borders (M2 total plication count = 7). They differ from those of

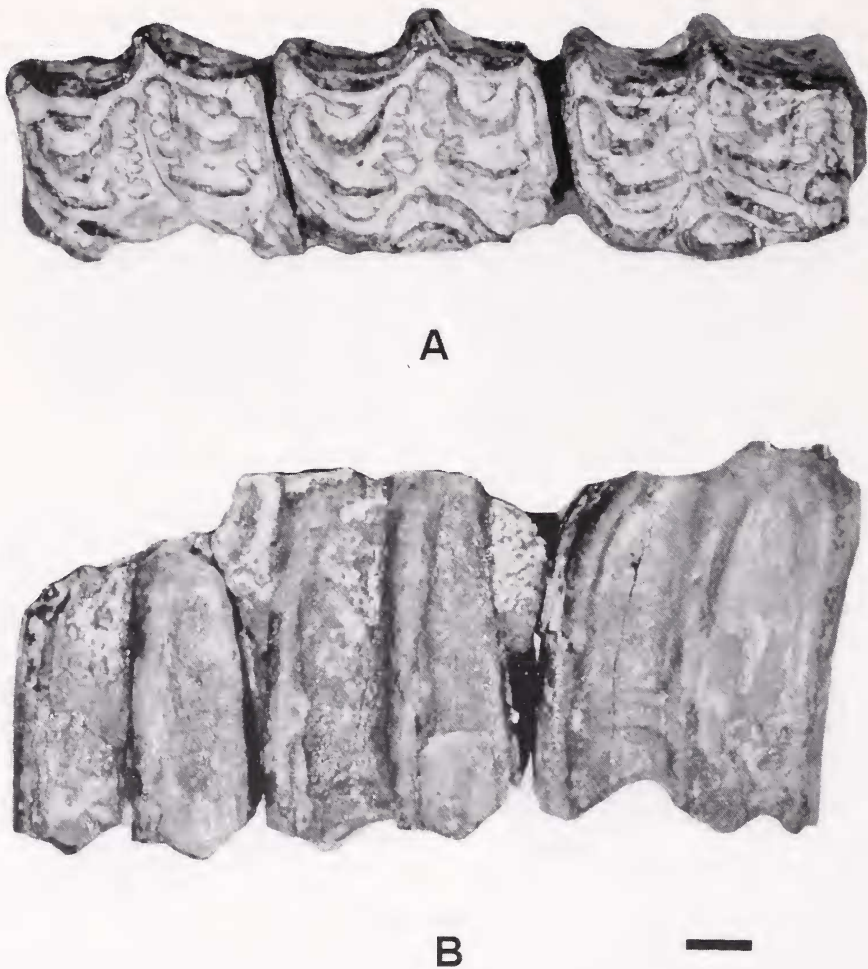


Figure 11 *Hipparion tehonense* from locality LACM 7665, Oro Loma Formation. A–B, associated partial LM1–2 and LM3, LACM 152701: A, occlusal view; B, labial view. Scale = 5 mm

Neohipparion eurystyle by their larger size, rounded parastyles and mesostyles (not prominently flattened), protocones less anteroposteriorly elongated, deeper ectoflexids (especially in lower molars), and less complicated plis caballinid (single fold, instead of multiple folds). They

differ from those of *Neohipparion affine* (Leidy, 1869) by having more complex fossette borders (M2 total plication count = 7), greater hypsodonty, and more elongated protocones. They differs from those of *Neohipparion gidleyi* Merriam, 1915a, by their smaller size, less elongated protocones, and less elongated and flattened parastyles and mesostyles, deeper ectoflexids, less elongated plis caballinid, and less hypsodonty. Merriam (1915a) described *Neohipparion molle* based on an isolated upper molar (UCMP 21370) from the Mack Pumping Station 3 locality (UCMP V-2076), Jacalitos Formation, north Coalinga region, California. The type molar was barely beginning to wear, so it was sectioned to show the occlusal pattern. MacFadden (1984) regards the type of *N. molle* to be from the Etchegoin Formation instead (= Jacalitos Formation of Merriam, 1915b) and probably a junior synonym of *N. eurystyle* based on its size, protocone length, and fossette complexity. The

Table 7 Measurements (in mm) of *Hipparion tehonense* from Oro Loma Formation

LACM specimen number	Position/dimension	Measurement
152701	M1 A-P	18.3
	TR	—
	M2 A-P	19.6
	TR	—
	Protocone A-P	6.4
	M3 A-P	20.5
	TR	16.8
	Protocone A-P	6.5
	Protocone TR	3.6

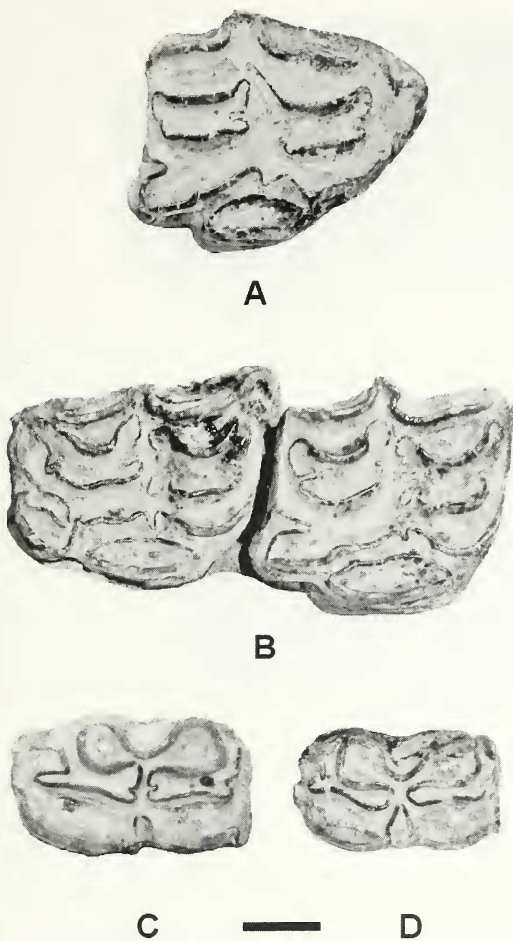


Figure 12 *Neohipparion leptode* from locality LACM 7666, Oro Loma Formation. A, RP2, LACM 152702; B, RM2-3, LACM 152704; C, Rp3 or 4, LACM 152705; D, partial Rm1 or 2, LACM 152706. All occlusal views. Scale = 10 mm

upper molars of *N. leptode* from LACM 7666 differ from the type of *N. molle* by being much larger in size and by having less angular anterior and posterior protocone borders.

Table 8 Measurements (in mm) of *Neohipparion leptode* from the Oro Loma Formation

LACM specimen number	Position/dimension	Measurement
152702	RP2 A-P	28.8
	TR	23.3
152704	RM2 A-P	23.3
	TR	23.8
	RM3 A-P	27.2
	TR	21.6
152705	Rp3 or 4 A-P	24.7
	TR	14.0
152706	Rm1 or 2 A-P	22.3
	TR	12.8

Dinohippus Quinn, 1955
Dinohippus spp.
Figures 13–14, Tables 9–10

REFERRED SPECIMENS. The *Dinohippus* material came from three different localities in the Oro Loma Formation and one locality to the south of Monocline Ridge in the unnamed nonmarine sediments of Dibblee (1975). From locality LACM 7666, Oro Loma Formation: partial palate with partial RdP2, RdP3–P4, and LdP2–P4, LACM 152707. From locality LACM 7667, Oro Loma Formation: partial right upper cheek tooth, LACM 152727. From locality LACM 7664, Oro Loma Formation: partial right upper cheek tooth, LACM 152700. From locality LACM 7668, unnamed nonmarine sediments: two associated partial left lower cheek teeth, LACM 152728. Due to their conspecificity not being demonstrable, each specimen from each locality is described and discussed separately below.

DESCRIPTION. Specimen from locality LACM 7666. LACM 152707 consists of a partial palate with partial RdP2, RdP3, RP4, partial LdP2, LdP3, and LP4 (Figure 13). The deciduous upper premolars are moderately well worn (LdP3 mesostylar crown height = 13.2 mm) and exhibit the following characters: (1) moderately simple occlusal fossette enamel borders (single pli protocone, no pli postfossette, and a small indistinct pli hypostyle); (2) a single moderately developed pli caballin; (3) a rounded oval protocone that is attached to the protoloph; (4) a small hypoconal groove on dP3 (lacking on dP2); and (5) very heavy cement. The P4s are in very early wear (<5%) so the occlusal enamel patterns are not yet exposed (Figure 13). However, even in their very early wear stage, the protocones are beginning to attach to the protolophs and, with greater wear, the protocones would develop rounded oval occlusal patterns. The P4 hypoconal grooves extend down to within about 12 mm of the base of the crown. The P4s exhibit moderate curvature (ROC = 55 mm) and are hypsodont (mesostylar crown height = 70 mm).

DISCUSSION. Specimen from locality LACM 7666. The specimen can be confidently assigned to *Dinohippus* s.l. based on the rounded oval protocones that are attached to the protolophs, the curvature of the permanent cheek teeth, and the degree of hypsodonty (Kelly, 1998). The *Dinohippus* teeth from LACM 7666 are more derived than those of the late Clarendonian “*Dinohippus*” *leardi* (Drescher, 1941) from Black Hawk Ranch, California (Kelly, 1998), by their larger size and by having slightly less curvature, slightly greater hypsodonty, and hypoconal grooves that extend farther down the crowns. The degree of extension of the hypoconal groove down the crown (see Kelly, 1998) is similar to that of early to early late “*Dinohippus*” *spectans*

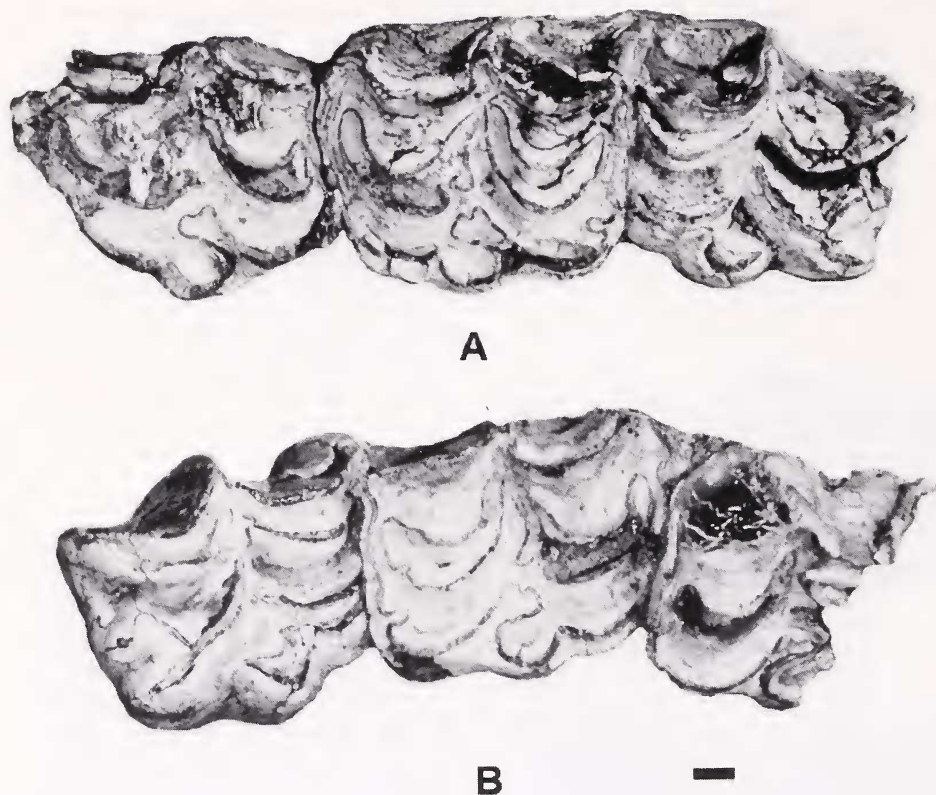


Figure 13 *Dinohippus* sp. from locality LACM 7666, Oro Loma Formation. A, partial LdP2, LdP3, and P4; B, partial RdP2-3, and P4, LACM 152707. All occlusal views. Scale = 10 mm

(Cope, 1880a) and slightly less than that of the early late to late Hemphillian "*Dinohippus*" *interpolatus* (Cope, 1893), "*Dinohippus*" *mexicanus* (Lance, 1950), and *Dinohippus leidyanus* (Osborn, 1918). Merriam (1914, 1915b) described *Pliohippus coalingensis* based on an isolated upper premolar (UCMP 21341) from the "Etchegoin" Formation (Mack Pumping Station, site 2, UCMP V-2073), North Coalinga area, California. Kelly (1998) regarded *P. coalingensis* as a nomen dubium and the type specimen as representing an indeterminate species of *Dinohippus* s.l. The *Dinohippus* teeth from LACM 7666 differ from the type of *P. coalingensis* by their larger size (Table 9). The *Dinohippus* specimen from LACM 7666 probably represents a different species from the *Dinohippus* specimens from localities LACM 7667 and 7664 because it is less derived by having hypoconal grooves that do not extend as far down the crowns. The specimen from LACM 7666 appears to be most similar in dental morphology to the early to early late Hemphillian representatives of *Dinohippus*, but a specific assignment must await a better sample from LACM 7666.

DESCRIPTION. Specimen from locality LACM 7667. LACM 152727 is a partial right upper cheek tooth in early wear that is missing

part of the crown portion of the ectoloph and the fossettes (Figure 14A). Despite being broken away, the fossette patterns are still discernable and are simple. The protocone is attached to the protoloph by a narrow isthmus. The protocone is elongated anteroposteriorly and narrow transversely, which is typical of dinohippine teeth in early wear. With greater wear the protocone would assume a more rounded, slightly elongated oval occlusal pattern. A distinct hypoconal groove is present that extends to near the base of the crown. The curvature of the tooth is moderate (ROC = 51 mm). The mesostylar crown height is estimated to have been about 55 mm. The tooth could not be measured at the occlusal surface because the upper labial portion of the crown is broken away. However, measurements were taken one-third of the way down the crown where the tooth is whole (Table 10).

DISCUSSION. Specimen from locality LACM 7667. LACM 152727 is referred to *Dinohippus* s.l. based on the following characters: (1) simple fossette enamel borders, (2) protocone attached to the protoloph, (3) moderate curvature, and (4) hypsodonty. The specimen is more derived than "*D.*" *leardi* and "*D.*" *spectans* by having a hypoconal groove that extends to the base of the crown, similar to those of "*D.*" *interpolatus* and *D.*

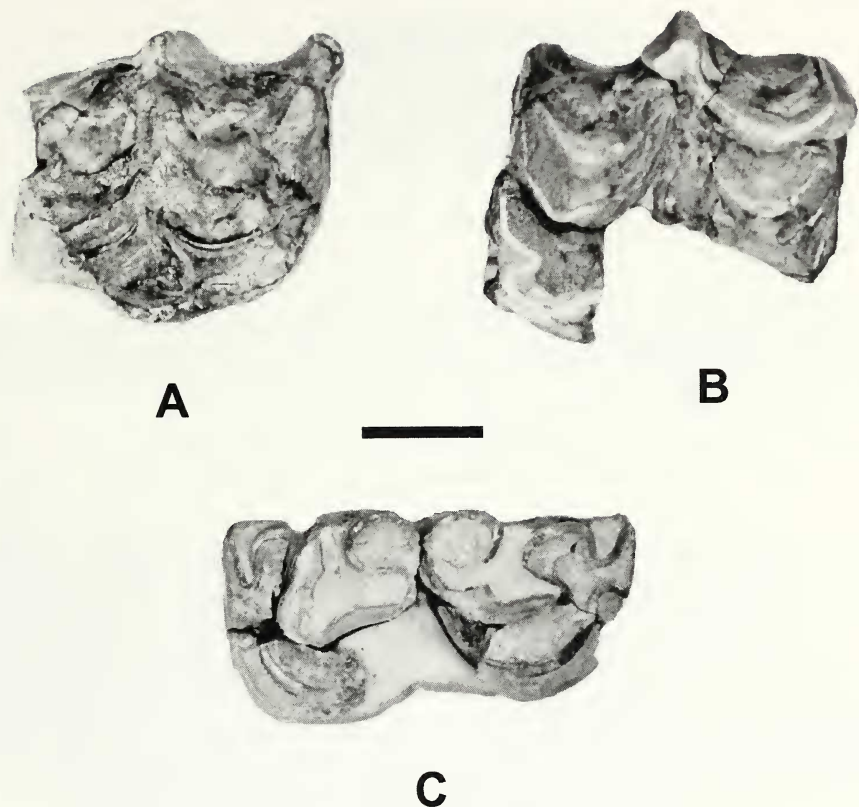


Figure 14 *Dinohippus* spp. from Oro Loma Formation (LACM 7664 and 7667) and unnamed nonmarine sediments (LACM 7668). A, partial right upper cheek tooth, LACM 152727, from locality LACM 7667; B, partial right upper cheek tooth, LACM 152700, from locality LACM 7664; C, partial left lower cheek tooth, LACM 152728, from locality LACM 7668. All occlusal views. Scale = 10 mm

Table 9 Measurements (in mm) of *Dinohippus* sp. from LACM 7666, Oro Loma Formation. ABBREVIATION: a = approximate

LACM specimen number	Position/dimension	Measurement
152707	LdP2 A-P	33.4a
	TR	27.9a
	Protocone A-P	6.5
	Protocone TR	6.4
	RdP2 A-P	—
	TR	28.3a
	LdP3 A-P	34.1a
	TR	27.8
	Protocone A-P	7.7
	Protocone TR	6.2
	RdP3 A-P	33.9
	TR	26.0a
	Protocone A-P	7.6
	Protocone TR	6.1
	LP4 A-P	34.7
	TR	27.2
RP4 A-P		34.9
	TR	26.7

leidyianus. LACM 152727 appears to be more derived than the *Dinohippus* specimen from locality LACM 7666 by having a hypoconal groove that extends farther down the crown, and may represent a different species. The specimen from locality LACM 7667 is similar in size to the type of “*Dinohippus coalingensis*” (Merriam, 1914), but specific diagnoses of dinohippine horses require much more complete material, preferably with cranial and facial morphology. Thus, LACM 152727 is referred to *Dinohippus* sp.

Table 10 Measurements (in mm) of *Dinohippus* spp. from upper part of Oro Loma Formation and unnamed nonmarine sediments of Dibblee (1975). ABBREVIATION: a = approximate

LACM specimen number	Position/dimension	Measurement
152727	Upper cheek tooth A-P	23.2
	TR	21.4
152700	Upper cheek tooth A-P	25.4
	TR	—
152728	Lower cheek tooth A-P	30.4a
	TR	16.1a

DESCRIPTION. Specimen from locality LACM 7664. LACM 152700 is a partial right upper cheek tooth in early moderate wear that is missing the protocone, part of the metaloph, and the protoloph (Figure 14B). The fossette enamel borders are simple. The hypoconal groove extends all the way down the crown. The mesostylar crown height is 47.5 mm. The curvature is moderate (ROC = 54.3 mm).

DISCUSSION. Specimen from locality LACM 7664. Based on the simple fossette borders, moderate curvature, and degree of hypsodonty, LACM 152700 is referred to *Dinohippus* s.l. The specimen from locality LACM 7664 is similar in size and dental morphology to LACM 152727 from locality LACM 7667 and may represent the same species, but a specific diagnosis for these specimens cannot be made until more complete material is available.

DESCRIPTION. Specimen from locality LACM 7668. LACM 152728 consists of fragments of two partial lower left cheek teeth in early moderate wear. The associated fragments of one tooth can be reasonably assembled back in position to reveal the characters of the tooth (Figure 14C). The reassembled tooth exhibits the following characters: (1) simple fossettid enamel borders, (2) protostylid lacking, (3) rounded and not widely separated metaconid and metastylid, (4) a shallow V-shaped lingua flexid, (5) heavy cement, (6) moderate hypsodonty (estimated metastylid crown height = 53 mm), and (7) moderately large size (Table 10).

DISCUSSION. Specimen from locality LACM 7668. All of the above characters are typical of species of *Dinohippus* s.l. and this specimen can be confidently referred to this taxon.

Artiodactyla Owen, 1848

Camelidae Gray, 1821

Miolabis Hay, 1899

Miolabis sp.

Figure 15, Table 11

REFERRED SPECIMENS. From locality V-99563: partial LM1, UCMP 166154; partial right maxilla with M2-3, UCMP 166157; partial left dentary with p2-m3, UCMP 166134.

DESCRIPTION. The upper molars of the partial maxilla and the partial M1 are of typical camelid structure. They exhibit prominent parastyles and mesostyles, and are relatively low-crowned. The anterior portion of the horizontal ramus is preserved for about 16 mm anterior to the p2, wherein it appears to widen labially (although crushed) to form the posterior portion of the mandibular symphysis. Thus, the diastema anterior to p2 is at minimum this distance. There is no indication of an alveolus for p1 within the diastema along the ramus. The premolars (p2-4) are characterized by the following: (1) moderately reduced size relative to the molars (p2-4/p2-m3

ratio = 35%, p2-4/m1-3 ratio = 53%, and p3-4/m1-3 ratio = 38%); (2) two-rooted p2, only slightly smaller anteroposteriorly than p3; (3) p2-p3 diastema lacking; (4) posterior TR width of p4 wider than medial TR width across the protoconid; and (5) posterior aspect of p4 moderately crowded into the anterior portion of m1. The lower molars are characterized by the following: (1) only slight crowding into each other anteroposteriorly, (2) prominent mesostylids, (3) absence of protostylids, and (4) no overlap of m3 entostylid onto hypoconulid.

DISCUSSION. The size of the Temblor camel is similar to *Procamelus occidentalis* (Leidy, 1858) from Lapara Creek, Texas, and *Miolabis fissidens* (Cope, 1876) from Pawnee Creek, Colorado. The Temblor camel differs from species of *Procamelus* Leidy, 1858, and *Protolabis* Cope, 1876, by having less reduction of the premolars relative to the molars. For example, in *Procamelus grandis* Leidy, 1858, the p2-4/p2-m3 ratio = 28-32% and the p2-4/m1-3 ratio = 37-46% (Gregory, 1942; Webb, 1969). The Temblor camel further differs from species of *Procamelus* and *Protolabis* by having well-developed molar metastylids. Also, in *Protolabis* the width of the posterior cusp of p4 is usually less than the width of the middle cusp, whereas in the Temblor camel the opposite is true. Furthermore, in *Protolabis* the p2-4 are shorter and more brachyodont with p2 commonly lost in more derived species, whereas in the Temblor camel the p2 is as tall as p3 and only slightly smaller than p3. The dental characteristics of the Temblor camel are indistinguishable from those of certain species of *Miolabis*.

Seven species of *Miolabis* are currently recognized (Kelly, 1992; Honey et al., 1998): *Miolabis californicus* Maxson, 1930, from Tick Canyon, California; *Miolabis transmontanus* (Cope, 1879) from Mascall, Oregon; *Miolabis princetonianus* (Sinclair, 1915) from Lower Snake Creek, Nebraska; *M. fissidens* from Pawnee Creek, Colorado; *Miolabis longiceps* (Matthew, 1909) from the Ogallala Group, Nebraska; *Miolabis fricki* Kelly, 1992 from Cuyama, California; and *Miolabis montanus* (Douglass, 1899) from "Miocene beds," Montana. The Arikareean *M. californicus* is the most primitive species. The Temblor camel differs from *M. californicus* by its larger size and slightly more reduced premolars relative to the molars. The Temblor camel is slightly larger than the earliest Barstovian *M. transmontanus*, which is only known from the type skull. The Temblor camel differs from the latest Hemingfordian to early late Barstovian *M. fricki* by its smaller size and lack of an overlapping entostylid onto the hypoconulid. The early to early late Barstovian *M. fissidens*, *M. longiceps*, and *M. montanus* are extremely similar in dental morphology and size. It is possible that they are very closely related species or, more likely, with

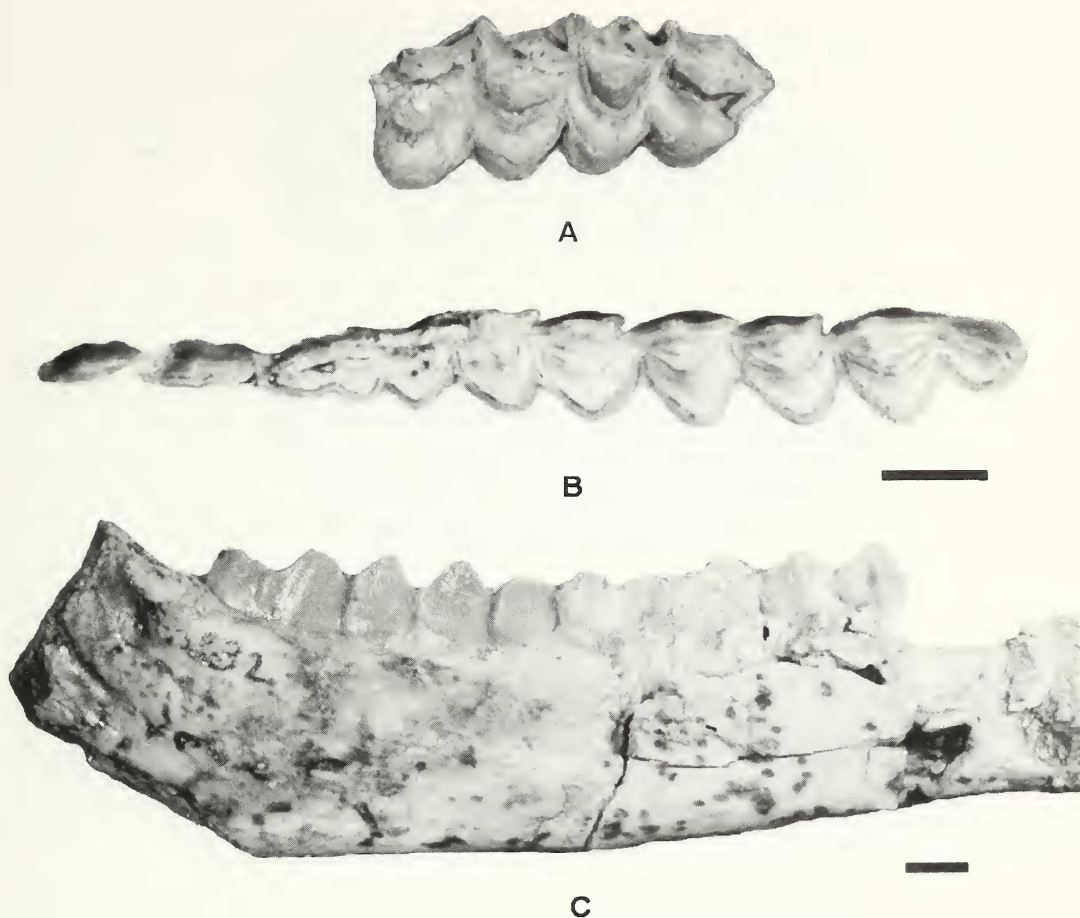


Figure 15 *Miolabis* sp. from Temblor Formation. A, LM2-3, UCMP 166157; B, Lp2-m3, UCMP 166134; C, partial dentary with Lp2-m3, UCMP 166134: A-B occlusal views; C lingual view. Upper scale for A-B = 10 mm, lower scale for C = 10 mm

revision of the genus it will be found that they all represent the same species (Kelly, 1992). For now, these species are referred to the *M. fissidens* species group, with *fissidens* having priority over the other species names (Cope, 1876). *Miolabis* sp. has also been reported from the Barstovian Bopesta Formation of California (Quinn, 1984, 1987), which also appears to belong to the *M. fissidens* species group (Kelly, 1992). The Temblor camel fits well within the size, proportions, and dental morphology of the *M. fissidens* species group and can be confidently assigned to *Miolabis*. However, until the genus is revised and synonymies established, the Temblor camel is referred to *Miolabis* sp.

Alforjas Harrison, 1979
Alforjas sp.

Figure 16, Table 12

REFERRED SPECIMENS. From locality LACM 7666: partial right maxilla with partial M1 and M2-3, LACM 152708; partial left

dentary with p3-m3, LACM 152709; partial metapodial, LACM 152710.

DESCRIPTION. The specimens are characterized by the following: (1) moderately large size; (2) moderately well-developed upper molar external stylids; (3) p2 absent; (4) p3 two-rooted; (5) p3-4 moderately reduced relative to molars; (6) lower premolars and molars narrow; that is, TR width relative to the A-P length is narrower than in most camel species, giving the cheek teeth an elongated appearance; and (7) weak lower molar protostylids. The cheek teeth are relatively hypsodont even though they are in moderately late wear.

The partial metapodial is large with a proximal TR width of about 65 mm.

DISCUSSION. The camel from LACM 7666 differs from *Procamelus*, *Hesperocamelus* Macdonald, 1949, *Megatylopus primaevus* Patton, 1969, and most species of *Aepycamelus* Macdonald, 1956, by the loss of p2 and the transversely narrowed cheek teeth. It differs from other species of *Megatylopus* Matthew and Cook, 1909, (*Megatylopus*

Table 11 Measurements (in mm) of *Miolabis* sp. from Temblor Formation. ABBREVIATION: a = approximate

UCMP specimen number	Position/dimension	Measurement
166157	M2 A-P	24.1a
	TR	18.9
	M3 A-P	25.9
166134	TR	18.0
	p2 A-P	11.4
	TR	4.0
	P3 A-P	12.2
	TR	4.9
	p4 A-P	13.7
	TR	7.0
	m1 A-P	16.1
	TR	11.5
	m2 A-P	22.1
	TR	12.3
	m3 A-P	30.0
	TR	12.1
	p2-4 A-P	35.7
	p3-4 A-P	25.4
	m1-3 A-P	66.9
	p3-m3 A-P	91.0
	p2-m3 A-P	102.7
	Depth of dentary below m1	30.4
	Depth of dentary below m2	32.2
	Depth of dentary below m3	36.2

gigas Matthew and Cook, 1909, and *Megatylopus cochrani* [Hibbard and Riggs, 1949]) and *Megacamelus* Frick, 1929 (*Megacamelus merriami* [Frick, 1921]) by its smaller size, lower molars with protostylids, and transversely narrowed cheek teeth. It is very similar to *Alforjas taylora* Harrison, 1979, including the following shared characters: (1) p2 absent, (2) p3 two-rooted, (3) weak lower molar protostylids (= llama buttresses), and (4) transversely narrowed cheek teeth. In size and proportions, all measurements fit well with the observed range for *A. taylora* (Harrison, 1979) except for the following: (1) the TR width of M2 (31.0 mm) is slightly greater (O.R. of *A. taylora* = 22.8–28.6 mm), (2) the TR width of M3 (29.8 mm) is slightly greater (O.R. of *A. taylora* = 20.0–25.1), and (3) the size of m3 (48.7 mm A-P and 19.2 mm TR) is slightly larger (O.R. of *A. taylora* = 38.5–46.5 mm A-P and 13.1–18.9 mm TR). Also, the protostylids are slightly weaker than those of *A. taylora*, but this may be due to the wear state of the lower molars of the specimen from LACM 7666. These differences are very minor and may not be significant. However, until a larger and more complete sample of the camel from LACM 7666 is available, it is herein referred to *Alforjas* sp. The partial metapodial is tentatively referred to this species because its size is comparable to those of *A. taylora* (Harrison, 1979).

Camelidae, genera and species indeterminate

REFERRED SPECIMENS. From locality V-99563: astragala, UCMP 166130, 166150, 166166, 166174; calcanea, UCMP 166153, 166167; first phalanges, UCMP 166129, 166138, 166164; second phalanx, UCMP 166162.

DISCUSSION. Several astragali, calcanea, and phalanges are recorded from V-99563. These specimens are grouped into two sizes. For example, three of the astragali range from 52 to 54 mm in height, whereas the other single astragalus measures 65 mm in height. Whether the single larger astragalus represents a different species from the other three smaller ones cannot be determined at this time because a variation of 10 to 12 mm in height of the astragalus can be seen in other medium-sized camels. All the astragali are much too large to be assigned to the small camel, *Miolabis* sp. from V-99563. The calcanea and phalanges also exhibit two size classes. Therefore, at least one additional species of camel, and perhaps two, are represented in the fauna from V-99563.

Antilocapridae Gray, 1866
Cosorycinae Cope, 1887
Cosorycinae, genus and species indeterminate

REFERRED SPECIMEN. From locality V-99563, partial right m3, UCMP uncataloged specimen (field number G-089).

DISCUSSION. The specimen consists of a partial right m3 with the hypoconulid missing. The following dimensions could be measured: the A-P from the parastylid to the entostylid equals 14.1 mm and the TR equals 7.2 mm. The partial tooth is characteristic of those of the Cosorycinae (= Merycodontinae Matthew, 1909) and can be confidently assigned to this subfamily. “Merycodont” antilocaprids are diagnosed primarily by their horn morphology, so specific assignment of this specimen is not possible. However, based on its size, it appears to represent a relatively large species.

AGE OF LOCALITIES

AGE OF FAUNA FROM LOCALITY UCMP V-99563

“*Merychippus*” *californicus* is known from the following early to early late Barstovian faunas of the West Coast and Great Basin (Bode, 1935a, b; Stirton, 1940b; Tedford et al., 1987, 2004; Kelly and Lander, 1988): (1) early Barstovian North Coalinga lf of the Merychippus Zone, Temblor Formation, California; (2) early Barstovian Virgin Valley Fauna, Virgin Valley Formation, Nevada; (3) early late Barstovian High Rock Lake Fauna, Virgin Valley Formation, Nevada; and (4) the early Barstovian Stewart Spring Fauna, “Esmeralda Formation,” Nevada. “*Merychippus*” cf.

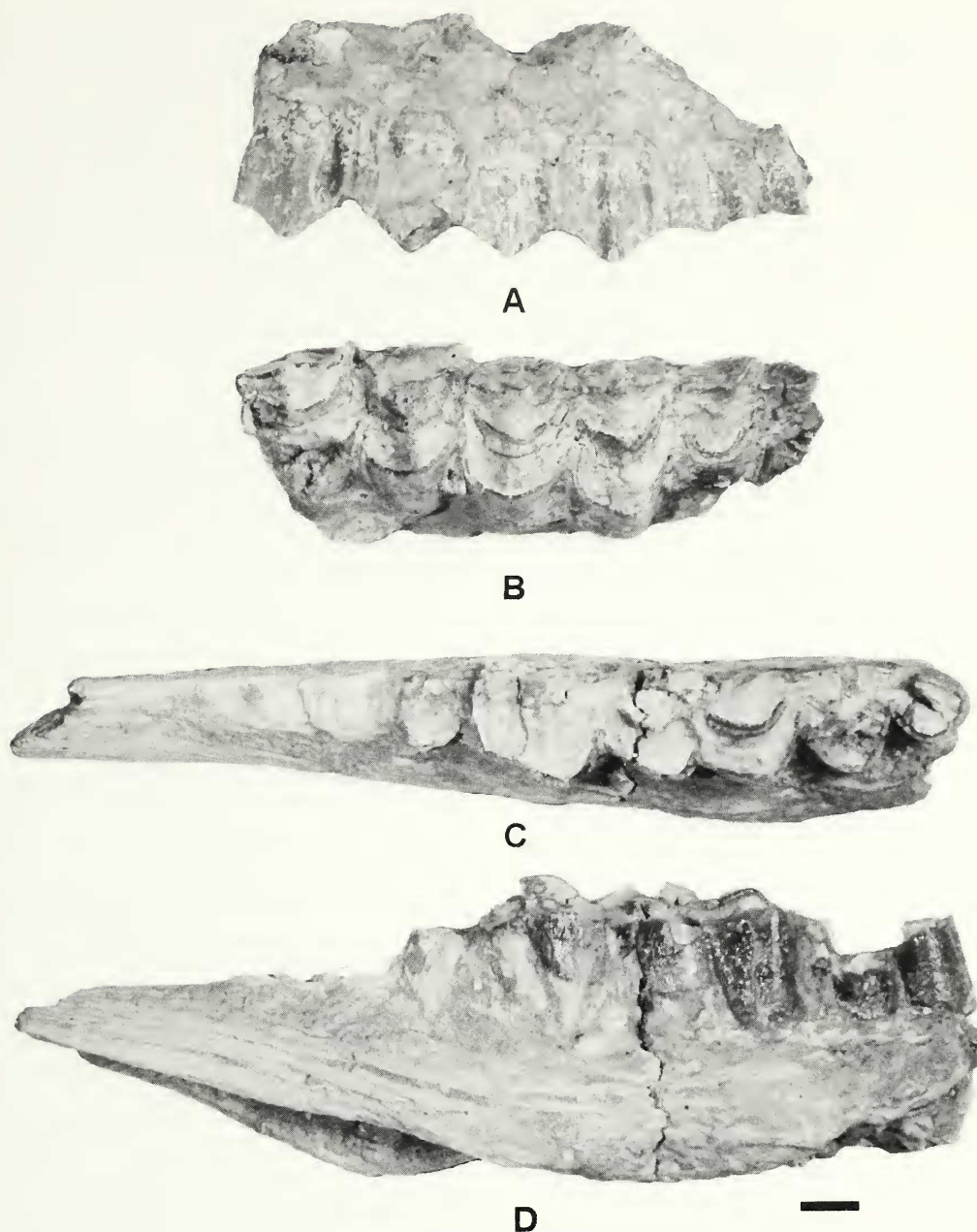


Figure 16 *Alforjas* sp. from locality LACM 7666, Oro Loma Formation. A–B, partial right maxilla with partial M1, M2, and partial M3, LACM 152708; C–D, partial left dentary with roots of p3–4, partial m1, m2, and partial m3, LACM 152709; A and C occlusal views; B and D labial views. Scale = 10 mm

“*M.*” *californicus* has also been reported from the Barstovian Red Zone Phosphoria Mine and Bradley Mine Faunas, Bone Valley Formation, Florida (Hulbert, 1988).

The North Coalinga Fauna is regarded by Tedford et al. (2004) as early Barstovian in age based on the taxonomic composition and a reevaluation of the stratigraphic position of the fauna relative to the latest calibration of Relizian–Luisian

foraminiferal stage boundary at 15.7 Ma (Barron and Isaacs, 2001). The age of the Virgin Valley Fauna is bracketed by Ar–Ar dates of 15.18 Ma on ash from above the fossil horizon and 15.84 Ma on ash below the fossil horizon (Perkins et al., 1998; Tedford et al., 2004). The age of the High Rock Lake Fauna is indicated by a K–Ar date of 14.49 Ma for the Fly Tuff that occurs 8 m above the main fossil horizon (Swisher, 1992; Tedford et al., 2004). The

Table 12 Measurements (in mm) of *Alforjas* sp. from the Oro Loma Formation. ABBREVIATIONS: a = approximate; est. = estimated

LACM specimen number	Position/dimension	Measurement
152708	RM1 A-P	32est.
	TR	—
	RM2 A-P	38.4
	TR	31.0
	RM3 A-P	38.7
152709	TR	29.8
	p3 A-P	14.4 alveolar
	TR	7.3 alveolar
	p4 A-P	14.6 alveolar
	TR	8.7 alveolar
	m1 A-P	22.4 alveolar
	TR	17.3a, 13.8 alveolar
	m2 A-P	32.3
	TR	20.2
	m3 A-P	48.7
	TR	19.2
	p3–m3 A-P	130a alveolar
	m1–m3	105.4a, 101.8 alveolar

Stewart Spring Fauna occurs below an ash K–Ar-dated at 14.89 Ma (Swisher, 1992; Tedford et al., 2004). Thus, the geochronologic range of “*M.*” *californicus* appears to be bracketed on the West Coast from about 15.9 to 14.5 Ma, or early to early late Barstovian.

“*Merychippus*” *brevidentus* is known from the following (Bode, 1935a; Stirton, 1940a; James, 1963; Quinn, 1984, 1987; Tedford et al., 1987, 2004): (1) the early Barstovian North Coalinga lf, Temblor Formation, California; (2) the early Barstovian Sharktooth Hill lf, Round Mountain Silt, California; (3) the early late Barstovian “*Merychippus*” cf. “*M.*” *intermontanus* Range Zone of the Bopesta Formation, California; (4) the early late Barstovian Kent Quarry, Caliente Formation, California; (5) the early Barstovian Virgin Valley Fauna, Virgin Valley Formation, Nevada; (6) the early late Barstovian High Rock Lake Fauna, Virgin Valley Formation, Nevada; (7) the early late Barstovian Stewart Spring Fauna, “Esmeralda Formation”, Nevada; (8) the early Barstovian Red Basin Fauna, Oregon; and (9) the early Barstovian Sucker Creek and Skull Creek Faunas, Sucker Creek Formation, Oregon. “*Merychippus*” *brevidentus* often occurs in faunas containing “*M.*” *californicus* and, like “*M.*” *californicus*, has a geochronologic range from the early to early late Barstovian.

“*Merychippus*” *relictus* is a rare taxon primarily occurring in earliest to early Barstovian faunas from Oregon (Downs, 1956). It is not usually associated with faunas containing “*M.*” *californicus*, but instead usually occurs in faunas containing

Acritohippus isonesus, such as the Mascall Fauna of Oregon. Whether the single tooth referred to “*M.*” cf. “*M.*” *relictus* from the Temblor sample actually represents “*M.*” *relictus* cannot be determined confidently until additional material is available. However, the known geochronologic range of “*M.*” *relictus* does not rule out the possible occurrence of this taxon in the Temblor sample.

Desmatippus avus has been previously reported from the following early to early late Barstovian localities (Bode, 1935a; Scharf, 1935; Downs, 1956; Tedford et al., 1987, 2004): (1) North Coalinga, California; (2) Beatty Buttes and Mascall, Oregon; and (3) Virgin Valley and High Rock Lake, Nevada.

Archaeohippus mourningi is restricted in the Barstow Formation, California, from the Skyline Tuff to 10 m above the Skyline Tuff, an interval that Woodburne (1996) correlates with the upper part of Chron C5Bn of the Magnetic Polarity Time Scale. In the Caliente Formation, *A. mourningi* is restricted to the upper part of Chron C5Br through Chron C5Bn (Prothero et al., in press). Thus, where detailed magnetostratigraphic and biostratigraphic controls are available, *A. mourningi* appears to have a geochronologic range of about 15.8 to 14.8 Ma, or the early to early late Barstovian.

Miolabis fissidens is known from the early late Barstovian Barstow Fauna, Barstow Formation, California, and the early late Barstovian Upper Pawnee Creek Fauna, Pawnee Creek Formation, Colorado (Honey et al., 1998; Tedford et al., 2004). *Miolabis montanus* is known from the early late Barstovian Anceney lf, Madison Valley Formation, Colorado (Honey et al., 1998; Tedford et al., 2004). *Miolabis longiceps* is known from the early Barstovian of the lower part of the Ogallala Group (= Sand Canyon beds and equivalents), Nebraska (Honey et al., 1998; Tedford et al., 2004). These three species are very similar in size and dental morphology and comprise the *M. fissidens* species group (Kelly, 1992). *Miolabis* sp. from UCMP V-99563 is referable to this group.

In summary, the combined geochronologic ranges of the horses and camel in the Temblor sample from UCMP V-99563 support an early to early late Barstovian age for the fauna, or about 15.8 to 14.8 Ma. Furthermore, most of the horses from UCMP V-99563 are specifically identical to those from the North Coalinga lf of the *Merychippus* Zone, indicating that these two faunas are very close in age.

AGE OF LOCALITY LACM 7665

Hipparion tehonense was first described by Merriam (1916) as *Neohipparion gratum tehonensis* from the Chanac Formation, Tejon Hills, California. Subsequently, it was referred to *Nannippus tehonensis* (e.g., Stirton, 1939, 1940a; Drescher, 1941) and then, based on more

complete samples preserving the facial morphology, to *Hipparion* s.s. (MacFadden, 1984, 1988). *Hipparion tehonense* is now known from the Clarendonian of California, Nevada, Texas, Kansas, Nebraska, and South Dakota (MacFadden, 1984). Tedford et al. (2004) cited the first occurrence of *H. tehonense* as one of the autochthonous species defining the beginning of the medial Clarendonian (Cl2). On the West Coast, *H. tehonense* appears to be restricted to late early to medial Clarendonian faunas. Biostratigraphic, radiometric, and magnetostratigraphic data from Red Rock Canyon, Tejon Hills, and the Cuyama Badlands (Whistler and Burbank, 1992; Wilson and Prothero, 1997; Prothero et al., in press) indicate that *H. tehonense* is present from about the middle of Chron C5An through Chron C5r4 of the Magnetic Polarity Time Scale or about 12.3 to 10.5 Ma. These data appear to constrain the age of locality LACM 7665 to the early to medial Clarendonian (Cl1–Cl2; see Woodburne, 2004: 335).

AGE OF FAUNA FROM LOCALITY LACM 7666

The dental characters (curvature, hypsodonty, and degree of extension of hypoconal groove) of the *Dinohippus* specimen from LACM 7666 are most similar to those of early to early late Hemphillian representatives of the genus (see above).

The type of *Neohipparion leptode* is from the early Hemphillian Thousand Creek Beds of Nevada. Other dubious referrals to *N. cf. N. leptode* have been made by other investigators from various early to late Hemphillian localities (Alroy, 2002). However, in many cases the material has not been adequately described or confirmed. Hulbert (1987) regards *N. eurystyle* to be late Hemphillian in age and the late early Hemphillian sample of *Neohipparion* referred by MacFadden (1984) to *N. eurystyle* from the Ft-40 locality, Nebraska, to represent *N. leptode* because of its larger size and lack of the derived styles (characteristic of *N. eurystyle*). Hulbert (1987) also refers specimens from the Oshkosh Fauna (Hh2, Ash Hollow Formation, Nebraska), the Box T locality (Texas), and the Port of Entry locality (Oklahoma) to *N. leptode*. Hulbert (1987) regards late Clarendonian to early Hemphillian *N. trampasense* to be the ancestor of *N. leptode* and *N. eurystyle*, and regards the geochronologic range of *N. leptode* to be middle Hemphillian or about 7.5 to 6.5 Ma. Comparison of the fauna from the Thousand Creek Beds of Nevada to other Hemphillian faunas from the Great Basin indicates that it may be medial Hemphillian (= late early Hemphillian, Hh2) in age instead of early Hemphillian. However, Tedford et al. (2004) use the first appearance of *N. leptode* as one of the characterizing autochthonous species of the early Hemphillian (Hh1), whereas

they regard the first appearance of *N. eurystyle* as characterizing the late early Hemphillian (Hh2). This is the only reference to *N. leptode* in Tedford et al. (2004:218), so it must be assumed that they regard the occurrence of *N. leptode* in the Thousand Creek Beds to be early Hemphillian (Hh1) or older than 7.5 Ma. Hulbert's (1987) analysis is the most convincing because it is backed up by detailed morphological evidence. Thus, it appears that *N. leptode* has a geochronologic range of about 7.5 to 6.5 Ma, or the late early Hemphillian to early late Hemphillian (= medial Hemphillian).

Alforjas taylora was first described from the late Hemphillian Edson Quarry, Ogallala Formation, Kansas. Harrison (1979) regarded *Alforjas* as occurring in many mid- to late Hemphillian faunas of North America. Since then, additional material from other localities has been assigned to *Alforjas* sp., such as the early Hemphillian Popotosa Formation and the late early Hemphillian Wray and Kimball faunas (Honey et al., 1998). Honey et al. (1998) give a geochronologic range for *Alforjas* from the early Hemphillian to the late Hemphillian. Tedford et al. (2004) list the first appearance of *Alforjas* as one of the characteristic autochthonous taxa that define the beginning of the Hemphillian (Hh1).

In summary, the combined presence of *Neohipparion leptode*, *Dinohippus* sp., and *Alforjas* sp. from LACM 7666 confidently supports a Hemphillian age for the fauna. Furthermore, the geochronologic range of *N. leptode* would seem to further support a late early to early late (= medial) Hemphillian age for the fauna, or about 7.5 to 6.5 Ma (Hulbert, 1987).

AGE OF LOCALITIES LACM 7664, 7667, AND 7668

These localities yielded only fragmentary specimens of *Dinohippus*. Localities LACM 7664 and 7667 occur stratigraphically above locality LACM 7666 in the Oro Loma Formation and LACM 7668 occurs high in the section to the south in the unnamed nonmarine sediments of Dibblee (1975), indicating that these localities are younger than the fauna from LACM 7666, and are probably medial to late Hemphillian in age. In addition, the *Dinohippus* specimen from locality 7667 exhibits a hypoconal groove that extends farther down the base of the crown than the *Dinohippus* specimen from locality LACM 7666, a derived character state for the dinohippine lineage (Kelly, 1998), further supporting a medial to late Hemphillian age.

CONCLUSIONS

Four new superposed assemblages are now recognized from the uppermost Temblor Formation and the overlying Oro Loma Formation of

the Monocline Ridge area along the western San Joaquin Valley, Fresno County, California: the early to early late Barstovian Monocline Ridge assemblage from locality UCMP V-99563, the late early to medial Clarendonian middle Oro Loma assemblage from locality LACM 7665, the late early to medial Hemphillian upper Oro Loma assemblage from locality LACM 7666, and the medial to late Hemphillian uppermost Oro Loma assemblage from localities LACM 7667 and 7664. The Monocline Ridge assemblage consists of the following taxa: Anura, Colubridae, Testudinidae, Anatidae, *Branta* cf. *B. woolfendeni*, Podicipidae, Passeriformes, Lagomorpha, *Pseudaelurus marshi*, Mustelidae (new gen. and sp.), *Martes* cf. *M. glarea*, *Microtomarctus conferta*, Borophaginae, *Amphicyon ingens*, *Desmatippus avus*, *Archaeohippus mourningi*, "*Merychippus californicus*," "*Merychippus brevidontus*," "*Merychippus*" cf. "*M.*" *relictus*, *Miolabia* sp., Camelidae, gen. and sp. indet. (medium-sized); and Cosorycinae, gen. and sp. indet. The amphibians, tortoises, birds, and carnivores of the Monocline Ridge assemblage are under study by other investigators and will be documented elsewhere. The middle Oro Loma assemblage consists of *Hipparion tehonense*. The upper Oro Loma assemblage consists of the following taxa: *Dinohippus* sp., *Neohipparion leptode*, and *Alforjas* sp. The uppermost Oro Loma assemblage from two medial to late Hemphillian sites within the Oro Loma Formation and a single site to the south within the unnamed nonmarine sediments of Dibblee (1975) have yielded specimens of *Dinohippus*.

Prior to the discovery of the bone bed at locality V-99563, the only other major site yielding terrestrial vertebrate fossils from Miocene sediments in the Diablo Range was discovered near the community of Coalinga before 1915 (Merriam, 1914, 1915c). The bone bed at locality LACM 7666 is the first ever found in the Oro Loma Formation. The other new localities from the Oro Loma Formation provide additional clarification of the age of this unit. The vertebrate assemblages from Monocline Ridge are also highly significant because they represent one of the few areas in North America that contain three superposed faunas spanning three North American Land Mammal Ages.

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